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BULLETIN

no. 2

OF THE

SOUTH DAKOTA SCHOOL OF MINES.

NOTES ON THE
GEOLOGY AND MINERAL DEPOSITS
OF A PORTION OF THE
SOUTHERN BLACK HILLS.

RAPID CITY, SOUTH DAKOTA.
JANUARY, 1899.



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GENERAL GEOLOGY.

BY CLEOPHAS C. O'HARRA.

INTRODUCTORY.

It is the established custom of the State School of Mines to provide means for the field study of various geological, mineralogical and mining problems relating to the state. In accordance with this custom, a few weeks were spent by the school survey party in the Southern Black Hills during the past summer. The party for a portion of the time numbered six, including professors and students.* In so far as convenient, the work was carried on with the view of training the students of the party in the methods best adapted to the study of field geology. Every effort, however, was put forth in order that new facts might be gained which would aid in unravelling the geological history and the economic possibilities of the region.

It was with this latter idea definitely in view that our party selected for examination that portion of the pre-Cambrian rocks of the Southern Hills, which lies in the north central part of Custer county, southeast of Harney peak. More definitely, the particular area to which most of our attention was directed, may be described as bounded on the north by a line corresponding approximately with latitude $43^{\circ} 50'$, which crosses

*The author of this paper wishes to make particular acknowledgment to Professor McLaury for assistance rendered in connection with the field work.

the head-waters of Iron creek and Spokane creek (sometimes known as Little Squaw creek), on the east by the Cambrian quartzite,* on the south by French creek, and on the west by the meridian of $103^{\circ} 30'$ west longitude. The survey camp was situated in the west central part of the area seven miles N. 80° E. of Custer, and eight and one-half miles S. 12° W. of Keystone. In addition to the study in this area, several neighboring localities of especial interest were also visited.

The position of the area, with reference to the general Black Hills region, may be seen in the accompanying sketch map, figure 1.



FIGURE 1. SKETCH MAP SHOWING LOCATION OF AREA SURVEYED.

It is well known that of the large amount of valuable mineral products now obtained in the Black Hills, by far the larger part comes from the Northern Hills. This is particularly true of gold. The Southern Hills have hitherto produced only a comparatively small amount. However, diligent prospecting has revealed the fact that rich gold ore exists

there in areas of considerable extent and in one or more places, extremely handsome returns are now being realized. Little or no detailed scientific work has hitherto been carried on for the purpose of solving the economic problems of the gold-bearing rocks in the restricted area to be discussed in this paper. Our party has endeavored to supply, as best it could, the want in this direction.

*This is the so-called Potsdam of the Black Hills. During the time at our disposal only the general position of this contact line could be mapped.

TOPOGRAPHY.

Topographically the region is sharply separated into two divisions. A rather prominent but somewhat irregular line of ridges beginning a short distance west of Spokane and running in a general southwesterly direction marks the line of separation, (see the geological map, figure 4). The area to the west is occupied by granites, schists, and quartzites, the granite greatly predominating. East of the line of separation and including the line of ridges mentioned, the rocks are also granites, schists and quartzites, but, unlike the western area, the prevailing rocks here are quartzites. This diversity in rock character is the chief cause of the marked difference in topographic features.

The western topographic area is, in general, extremely rough and difficult to traverse. The granite is exposed in numerous mountain peaks, serrated ridges, slender pinnacles, sharp needles, and lenticular masses projecting frequently to considerable heights above the general surface. Newton, in the *Geology of the Black Hills** has described to some extent the general surface features of the granite district but no one can fully appreciate his graphic description of the delays and hardships encountered by his party in their attempt to reach Harney peak until he himself has tried to follow a direct course for several miles over this extremely rough granite surface. Here and there a small park is found which, when cleared of forest and properly irrigated, furnishes a fruitful field and a comfortable home for the careful ranchman. The numerous little angular valleys and small parks, as well as the high rounded shoulders of the larger peaks are generally covered by a considerable growth of pine trees, which conceal from the distant observer all but the clean precipitous sides of the higher granite masses, and thus add a pleasant charm to this most beautiful mountain scenery.

* Report on the Geology and Resources of the Black Hills of Dakota, with atlas. By Henry Newton, E. M., and Walter P. Jenney, E. M., Washington, 1880.

Figure 2 shows the granite area as seen from the top of Saddleback ridge looking toward Harney peak.

The surface of the eastern topographic area, although in many places quite rough and showing narrow ravines, deep gulches and precipitous canyons, has little or none of that rough jagged appearance of the granite area. Here the surface is undulating and the hillsides are generally covered by a heavy soil and a dense timber growth to the very top. Sharply rounded hills and narrow-crested, irregularly curving ridges separated by deep winding valleys are the rule. Figure 3 shows the surface features of this region as seen from near the top of Chilkoot hill, looking southward toward Sheep mountain.

DRAINAGE.

Battle creek and French creek drain the area, their waters flowing eastward into the prairie region and finally emptying into the south fork of the Cheyenne river. Of these, French creek, which in this part of the Hills is considerably the stronger of the two streams, drains only a small portion of the area, the divide being situated within two or three miles of the creek. Several small branches carry the water from the remainder of the area in a general northeasterly direction to Battle creek. Among these smaller streams are Iron creek, which joins Battle creek near Hayward and Squaw creek which flows into Battle creek two miles southwest of Hermosa. Squaw creek itself receives water from several smaller streams of some importance, the local names for which are Spokane creek (Little Squaw creek), Bear gulch, Middle Squaw creek and South Squaw creek. Some of these streams in various parts of their courses have cut deep gorges or canyons and throughout the upper part of their courses the descent is rapid. In their lower courses the current is less swift and in several cases the water sinks beneath the surface and disappears so that throughout much of the year this part of the stream bed is dry. Furthermore, on account of the deficiency of rainfall, many of the smaller stream beds, in the



FIGURE 2. GRANITE AREA AS SEEN FROM SADDLEBACK RIDGE. HARNEY PEAK IN THE DISTANCE.



FIGURE 3. QUARTZITE AREA AS SEEN FROM NEAR THE TOP OF CHILKOOT HILL. SHEEP MOUNTAIN IN THE DISTANCE.

more elevated portions of the area, are wholly dry throughout much of the year.

ALTITUDE.

The highest point in the area is Sheep mountain, near French creek, which reaches a height of 6050 feet above sea level.* North of this point the height over a considerable portion of the area is more than 5500 feet, and in the northwestern part one or two isolated granite peaks closely rival Sheep mountain in height. The lowest point is about 4000 feet, which altitude is reached along some of the creek beds near the eastern border of the area. For the whole area, the average elevation is perhaps not far from 5300 feet.

GEOLOGY.

As previously stated, the rocks of the area are granites, quartzites and schists (see figure 4). Granites

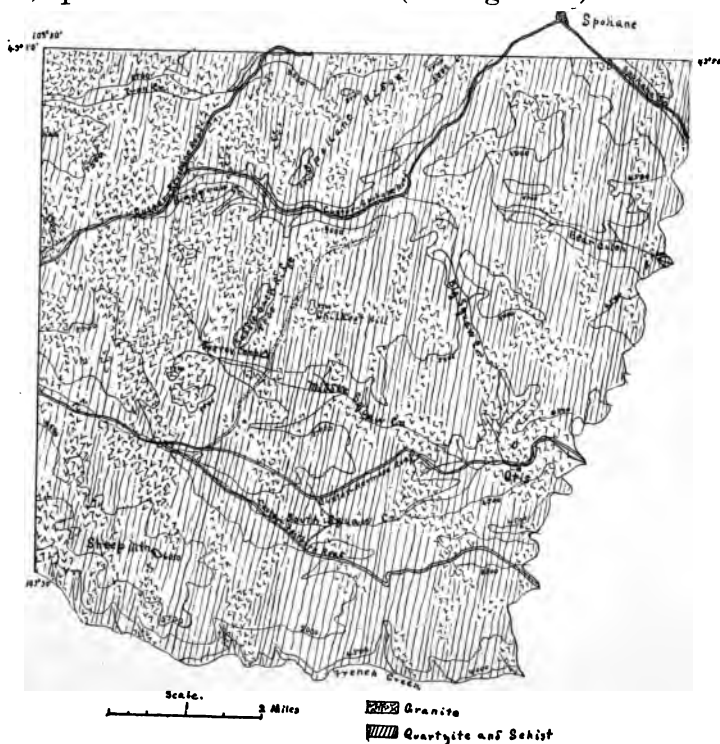


FIGURE 4. GEOLOGICAL MAP. TOPOGRAPHY REDUCED FROM HERMOSA SHEET, U. S. G. S., 1894.

* Hermosa sheet, U. S. G. S., 1894.

prevail in the western part, quartzites in the eastern. Schists are common to both. In this paper, we shall include all of these rocks under the name Pre-Cambrian, the authority for this being based on conclusive evidence. Newton, in discussing the age of the granite, says, in reference to the section along French creek, "A continuous sheet of Potsdam passes from a surface of eroded schist to a surface of granite. There was found no intrusion of the granite along the parting between the Potsdam and the schists and there was found no metamorphism of the Potsdam at the surface of contact with the granite.* Similar phenomena as well as additional evidence were found by Professor Headden in the vicinity of Hayward on Battle creek.† In several places examined by us between these sections, the evidence is as unmistakable. Figure 5 gives a view of the Cambrian quartzite, as shown on Squaw creek at the north side of the county road, one mile east of Otis. Here the Cambrian quartzite, the lowest part of which is frequently coarsely conglomerate, lies directly upon a medium coarse granite. Two exposures of the granite are shown in the plate, the largest one disclosing the contact line for a distance of twenty feet or more. The overlying Cambrian quartzite is wholly unchanged so far as affected by the presence of the granite.

Figure 6 shows a similar contact exposed on the north bank of Dry creek, two hundred yards north of the Custer-Fairburn road, a little more than a mile south-southeast of Otis. Here, however, the underlying coarse granite is present only in the form of clearly defined dikes which, having broken through the pre-Cambrian quartzite, extend upward to the Cambrian quartzite, where they are sharply truncated on a level with the eroded surface of the pre-Cambrian, which is unconformably overlain by the Cambrian quartzite. The

* Geology of the Black Hills of Dakota, p. 78.

† Van Hise, C. R. The Pre-Cambrian Rock of the Black Hills, Bull. G. S. A., Vol. I, p. 212, Washington, 1890.

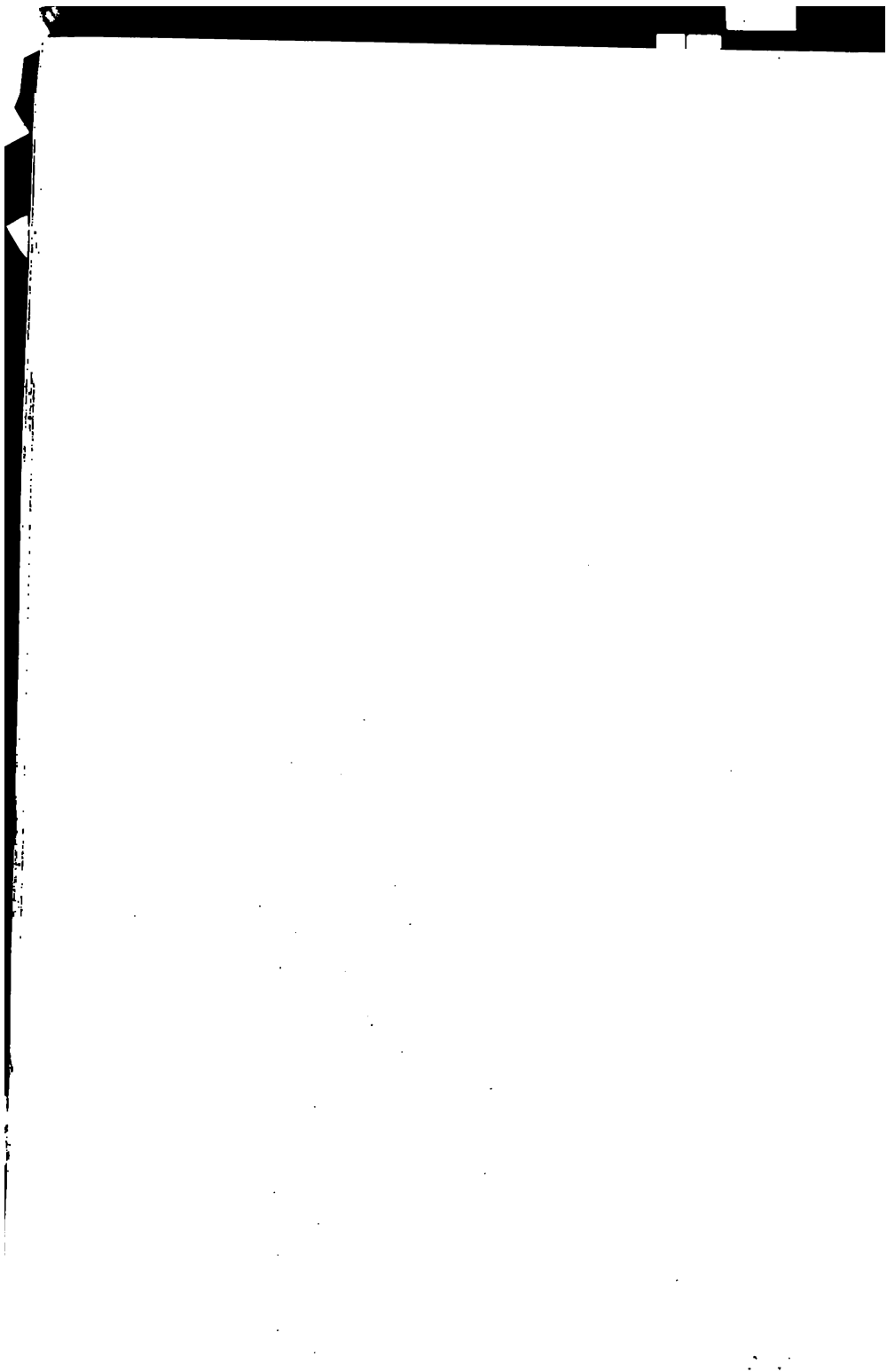


FIGURE 5. CAMBRIAN—PRE-CAMBRIAN CONTACT NEAR OTIS.

[REDACTED]



FIGURE 6. CAMBRIAN—PRE-CAMBRIAN CONTACT ON DRY CREEK.



dikes shown in the plate are pegmatitic in character, and are four in number. The one farthest east is ten inches thick, the next two inches, the third fourteen inches, and the fourth, the one farthest west, beneath the opening, is six feet.

Granite.—The granite is much the same in general character throughout the entire area. It is made up of white or pinkish feldspar, clear, smoky or rose quartz, and light or dark mica, besides numerous accessory minerals. Among the latter, tourmaline is particularly abundant. The percentage of feldspar is high. According to Newton, the Black Hills granite as a whole is made up of about 70 or 75 per cent of feldspar, 20 per cent of quartz and 5 per cent of mica.* The texture varies within rather wide limits but it is in general very coarse. Medium grained granite is not uncommon over considerable areas, but the finer varieties are almost wholly lacking. Much of the rock is made up of very large crystals and frequently instead of the several minerals being uniformly distributed throughout the mass each one is arranged in extremely irregular segregations. This prominent coarse nature of the crystals together with other phenomena has given rise to various views concerning the origin of the granite.† We shall make no attempt in the present paper to enter into the discussion of this question.

The granite does not represent a continuous phase of development. Over considerable areas the coarser granite, which among the prospectors and miners is known as "bull rock," appears to have no regularity of arrangement. More frequently the coarser portions run through the medium grained granite in the form of irregular streaks without any well marked line of sep-

* Geology of the Black Hills of Dakota, p. 70.

† Newton, Henry. Geology of the Black Hills of Dakota, 1880.

Carpenter, Franklin R. Notes on the Geology of the Black Hills. Preliminary Report of the Dakota School of Mines, 1888.

Crosby, W. O. Geology of the Black Hills of Dakota, 1888.

Van Hise, C. R. The Pre-Cambrian Rock of the Black Hills, 1890.

aration. In many places, however, the coarser material, which is pegmatitic in character and frequently partakes of the nature of graphic granite, is observed in distinct dikes, they being oftentimes found cutting through the body of medium grained granite as clearly and sharply defined as if outlined with a pencil. This feature is confined to no particular portion of the area studied, but it was found perhaps best developed south of Middle Squaw creek, about two miles north-north-west of Sheep mountain. Apparently many of the dikes, the outlines of which are irregular or obscure, are really formed in the same way as the more clearly defined dikes but unequal weathering of the general rock surface has in the case of the former obliterated that which would be clearly shown in a smooth cross section.

In many of the better defined dikes the texture at the edge is finer than toward the center, and not infrequently the crystals are arranged uniformly perpendicular to the wall of the dike. This feature is particularly prominent in the case of tourmaline when abundant crystals of this mineral occur in the narrower dikes. It is well known that the main masses of granite, which are generally lenticular in shape, run nearly parallel with the strike of the schists and quartzites as first pointed out by Newton.* The smaller dikes cut these in various directions.

Owing to the possible influence which they may have upon the economic development of the area, considerable attention was given to the study of the direction in which the dikes run. The results show that a large proportion of them extend radially toward Harney peak, but there seems so many exceptions that the observations are probably of little value.

Ordinarily the dikes wherever well exposed, whether in granite or in quartzite, weather more rapidly than the main mass of rock so that the position and direction of the dikes may be readily traced. This is par-

* Geology of the Black Hills of Dakota, p. 73.

ticularly true when the dikes cut through fine grained granite or quartzite. Here the coarse crystals easily disintegrate and shrubs and small trees quickly spring up to mark the line of rapid weathering. On the other hand, the dikes, when cutting through schistose rocks, are found generally to be less easily disintegrated than the schist, and therefore project above the general surface.

Metamorphic Rocks.—These include the schists and quartzites which are found intimately associated in varying quantity throughout the region studied, but which predominate only in the southern and eastern portions. They do not make up the entire rock mass over any extensive well defined area, granite being always present in greater or less amount in the form of dikes or irregular masses.

In the accompanying geological map an attempt has been made to indicate the relative proportions of the metamorphic rocks and the granite. The larger and more important areas are located and defined with some degree of accuracy but no effort has been made to reproduce in detail the intricate relations of the various rock-masses throughout the entire area. This was wholly incompatible with the time at our disposal, and, owing to the many difficulties to be encountered, could at best lead only to questionable results. For the distribution of the rocks in the immediate vicinity of our camp the reader is referred to the accompanying paper by Professor Forsyth.

In places, the original bedding of the metamorphic rocks is still discernible. An example of this may be seen at the roadside one-half mile west of Otis. A photograph of this out-crop, through which runs a dike of pegmatite is shown in figure 7. Areas in which quartzites abound are usually indicated by ridges. This feature is particularly prominent in the case of Spokane ridge, Saddleback ridge, and Sheep mountain, and is quite noticeable, although less pronounced, in many of the lower ridges and hills to the east. Localities occupied chiefly by schists are represented by valleys.

Owing, however, to the fact that the granite is also inclined to weather more rapidly than the heavy quartzite the schistose valleys are not so typical as are the quartzite ridges.

The schistose rocks are made up chiefly of quartz, biotite and feldspar, although in some restricted areas hornblende or garnet is a prominent constituent. Tourmaline is sometimes present, although never in abundance, and graphite is occasionally found. Muscovite sometimes takes the place of the biotite, and not infrequently these two minerals occur together. Biotite is, however, much the more common of the two minerals. The schists in which hornblende is the chief constituent are found in considerable abundance west, northwest and southwest of Otis. These appear to be highly metamorphosed basic igneous rocks, are sometimes gold-bearing,* and probably come within the class designated by Professor Van Hise as dioritic rocks which have partaken of the alteration effects of the forces that metamorphosed the fragmental series.† In color, they are very dark green, almost black, and wherever seen are inclined to be rather massive.

In the micaceous schists the biotite is present as medium brownish black flakes, pretty evenly distributed among the quartz granules. These flakes have in the main originated as a secondary product through the alteration of the original feldspar.‡ The feldspar is not particularly prominent in any case but the biotite and the quartz vary widely in amount present, the specimens collected showing almost all gradations from a highly crinkled, very dark, nearly quartzless schist, to a massive, evengrained, translucent quartzite.

The quartzites vary little in character, except at times they show by the presence and regular arrangement of mica or feldspar an approach to schistose conditions. They are usually compact and homogeneous,

* Carpenter, F. R. Notes on the Geology of the Black Hills, p. 25, 1888.

† The Pre-Cambrian Rock of the Black Hills, p. 230, 1890.

‡ Ibid, p. 223.



FIGURE 7. QUANTZITE EXPOSURE NEAR OTIS. PEGMATITE DIKE IN LOWER PART.



the purer varieties showing quartz as almost the only constituent. Clear, almost colorless, varieties are not uncommon but more often, owing to impurities, some shade of blue, green or red is noticeable.

Quartz veins varying in size from a mere line up to as much as fifty feet or more in thickness occur abundantly throughout the areas covered by the schists and quartzites. Many of these veins are gold-bearing and it is for this reason that their study has become of importance. Particular attention was paid to the relative age of these veins. They cut both quartzites and schists in every direction, hence the quartz veins are younger than these rocks. So far as could be learned, the hornblendi schists are not excepted, they being traversed by the veins in all cases in the same manner as are the micaceous schists. The quartz veins, however, are in turn cut by the pegmatite dikes so that at every place where observation was made, the veins proved to be older than the dikes. The importance which this feature may seem to have upon the economic development of the gold-bearing veins is discussed by Professor Forsyth in the accompanying paper of this bulletin. In some places, quartz veins were found traversing the main body of granite but these veins were nowhere prominent and in general they do not appear to be contemporaneous with nor similar to the gold-bearing veins.

The strike of the schists and quartzites is considerably east of north. In many exposures this is not easily made out, owing to the disturbing influences of the granite, but the ridges formed by the hard quartzite beds frequently indicate the direction with considerable accuracy. Spokane ridge and Saddleback ridge whose general direction is about N 35° E seem to follow the strike pretty closely.

Effort was made to determine the position and nature of folds if present. None of importance were located, the various disturbances having apparently obliterated the characteristic features of such folds as may have existed. Westerly dips were occasionally found, but in most cases observed the dip is to the east.

Joint planes, as might be expected, are well developed. The numerous heavy quartzite talus slopes throughout the area are largely made up of the rhombic blocks produced by these joint planes. In the granite areas these planes, although less abundant, have greatly aided weathering and it is to this fact that numerous rocking stones and many of the picturesque needle-like projections are due. As previously suggested the pegmatite dikes so common in many parts of the granite region weather more readily than the even grained granite which the dikes traverse and these may be observed in some places to have weathered out forming narrow crevices extending several feet below the general level of the granite mass thus simulating the effect of the joint planes. The granite only rarely produces talus slopes of joint blocks the fragments collected at the base of the cliffs being almost always fine and angular, forming a kind of granite gravel easily removed by erosive agents.

Irregular fragments of quartzite and schist imbedded as foreign bodies in the granite are of frequent occurrence. These masses, which in the miner's language may be termed "horses" are of all sizes up to many feet or yards in diameter.

Figure 8 shows one of these enclosed bodies exposed at the top of Saddleback ridge about one mile north of Little Squaw creek. The much jointed rock is the quartzite.

HISTORY.

The probable early geological history of the Southern Hills is briefly as follows: In Algonkian time the schists and quartzites were deposited as sediments derived from land lying apparently either to the west or to the northeast of the position now occupied by the Hills. Later, these original sediments were cut by basic eruptives at which time more or less metamorphism and folding were produced. Subsequent to this action the clastic rocks as well as the basic eruptives were ramified by quartz veins many of which are gold-



FIGURE 8. QUARTZITE ENCLOSED BY GRANITE.

bearing. Following* the eruption of the basic rocks and after most or all of the gold-bearing quartz veins were formed, extensive granite intrusions occurred. Apparently at the time of the intrusion of the basic eruptives the slaty cleavage was produced and approximately coincident with the granite intrusions, the crystalline schists and the schistose structure, so prominent in many parts of the Hills, was developed.† At some time during the middle or latter part of the Algonkian period the sea shallowed, and the land rising above the sea as an island, reached a considerable height. The rocks thus brought under the influence of erosive agents supplied the sediments which make up the Cambrian rocks surrounding the Hills.

NOTE.

Through the kindness of Messrs. A. Madill and William McGarrity, of Glendale, two members of the party were able to visit the placer mines at Hayward immediately after breaking camp. While there our attention was directed to a tunnel which had been driven several years ago into a hill on the south side of Battle creek, near the placer workings, a short distance west of town. The tunnel, which is known as the Broken Hill mine, is almost immediately beneath the Cambrian quartzite, and has penetrated very dark pyritous schist for a distance of perhaps a hundred feet. Near the entrance and extending back to the end of the tunnel, melanterite was found in considerable abundance, it having been formed in the presence of decomposing pyrite. So far as can be learned, melanterite has not hitherto been described as being found in the Hills, and as the beauty, freshness and quantity of the material is rather out of the ordinary, we deem it of sufficient importance to those interested in the mineralogy of the Black Hills to make mention of it here.

* Todd, J. E. A Preliminary Report on the Geology of South Dakota, p. 134, Sioux Falls, 1894.

† Van Hise, C. R. The Pre-Cambrian Rock of the Black Hills, p. 241, 1890.

The specimens of fresh material collected have a rich green color, and partake more or less of a fibrous nature. The partially dehydrated material is glossy white, and shows a prominent asbestiform structure. Fresh specimens quickly change to this condition, unless special care be taken to prevent it. The mineral, in a more decomposed state sometimes, although rarely, shows a slight yellowish tinge, and readily crumbles in the hand. Good crystals were not found.

The mineral occurs in stringers, sometimes two inches or more in thickness, which ramify the pyritous schist in various directions. The remarkable feature in connection with the deposit is, that delicately balanced conditions should prevail at or near the surface for a considerable length of time sufficiently stable to allow the formation of an easily soluble mineral in such abundance as is the melanterite at this place.

The chemical composition of the melanterite is peculiar. The percentage of ferrous sulphate is quite low. Potassium sulphate is present in considerable quantity, and free sulphuric acid is particularly prominent. The amount of water is also very high. Apparently the excellent preservation of the material is in considerable measure due to the presence of the free sulphuric acid. In the analysis which has been made no opportunity was given for the careful selection of fresh material, hence the exact results thus far obtained need not be given until other analysis are made.*

A minutely crystalized brownish or wine-colored mineral occurs in very small quantity with the melanterite. This mineral is also an iron sulphate. The general characters of the mineral indicate that it is amaranthite, although positive evidence of this has not yet been definitely established.

*The author is indebted to Mr. M. N. Bolles and Mr. L. M. French, students in the School of Mines, for the analytical work.

MINING GEOLOGY AND MINING.

BY A. FORSYTH.

I. INTRODUCTORY.

The object of this survey was twofold; first, to study geologically in the interest of mining and of pure science, a selected portion of the Black Hills; and second, to give to students of the School of Mines practical geological and topographical work in the field. This twofold object was, it is thought, in considerable measure attained.

The work of the students consisted mainly in making a careful topographical and geological map of a gold mining district. The work of the instructor was that of directing and assisting them, of studying with them, and of making notes and observations on mineral deposits at various points outside the area surveyed.

II. CHILKOOT GOLD MINING REGION.

Area Surveyed.—The black square within the cross-hatched area on the map, Figure 1, of the preceding paper, and also the triangle marked "Survey Camp" on the map, Figure 4 of the same paper, show the location of the region surveyed. It comprises about three-quarters of a square mile, and covers the more important gold quartz claims and prospect openings. On page 31 is the completed geological and topographical map.

This selected area gains interest from its newness and from some peculiar features of the occurrence of gold. There is the interest of studying future possibilities, of balancing the indications for and against future successful development.

The surface features of the country are pleasant and promising. The map shows portions of three hills. They are of the gracefully rounded shape characteristic of the quartzite ridges of the vicinity. They rise about 300 feet from the bottoms of the intervening val-

leys. The country is clothed with the heavy pine covering of the Southern Hills. Trees of two feet and more in diameter are abundant. Pine is practically the only tree found. The spruces of the Custer region are conspicuously absent. The timber is protected by the laws governing the Forest Reserve. Water is found both north and south of the area mapped. On the north is Big Squaw creek; on the south, Middle Squaw creek. These creeks with their tributary springs carry the clear cold water characteristic of the Algonkian area of the Hills.

Prospecting.—The first quartz locations in this vicinity were made in 1893. Previous to this there had been some placer exploration in the bottom of the gulches. With what success, it is not known. The claims located in 1893, were the Parrish, the Chilkoot and the Detroit, (map, p. 33.) In prospecting, the first ore sought was a quartzite, distinctive by a yellowish green cast. It was found to contain small gold values, (\$1.00 to \$2.00 per ton). The Parrish was located on this material, but further search for green rock disclosed to the prospectors white quartz veins of greater value. On such were staked the Chilkoot and Detroit. These veins range in width from one inch to two feet, and are credited with gold values of from \$20.00 to \$80.00 per ton, with rich spots running much higher. Much of the gold is free as shown by the pan tests.

The Rocks.—The rocks are members of the Algonkian system of the Hills*. Quartzite has already been mentioned as constituting the ore first sought. Besides this, there occur in the area mapped, mica schist, granite with a pegmatitic variation, and the quartz gold veins.

In age, from oldest to youngest, the order becomes:

1. Quartzite.
- (1 a). Mica Schist.
2. Quartz veins.
3. Granite. (Pegmatite.)

* See Dr. O'Harra's paper, p. 24.

The quartzite is hard, close grained, white in general appearance, but carrying in small grains a fair percentage of ferruginous matter.

Mica schist plays a very unimportant part in the small area under consideration. It occurs in several openings plainly as the result of dynamic metamorphism produced at the time of the shattering of the quartzite. On this evidence it gains its order, (1 a). This order is however provisional and may apply only to the small occurrence here considered. Two or three inches was the greatest thickness of schist observed. More extensive schistose masses occur not far outside the boundaries of the map. These however, cannot be here discussed.

The auriferous quartz veins cut quartzite but not granite. Figure 9 gives an example of the relations of quartzite, auriferous vein quartz, and granite. This sketch is of the Detroit opening. It is the type of several exposures in the vicinity. The relative age of granite and gold quartz here shown is most important to the prospector and miner. It naturally means that they must take into consideration chances of profitable veins being cut off by granite sheets and must calculate on the thickness and frequency of these sheets.

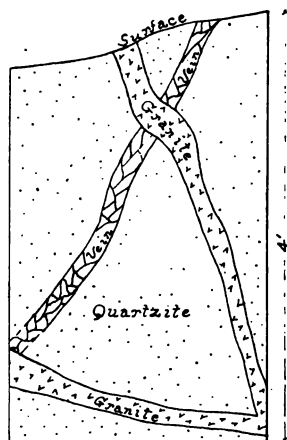


FIGURE 9. SHOWING RELATIONS OF QUARTZITE, GOLD QUARTZ AND GRANITE.

The gold quartz is clear, white and glassy. Characteristic of it are numerous small cavities 1-32 of an inch and less in diameter, containing little graphite crystals. In places there is much iron stain, possibly from pyrite oxidation. Pyrite unaltered does not yet appear in the present early stage of development. The gold occurs in very finely divided condition, usually more abundant in the iron stained portion.

The granite is that of the Harney Peak area. Fre-

quently it is pegmatitic in character. In fact it is an open question if all the granite in this region had not better be called pegmatite.*

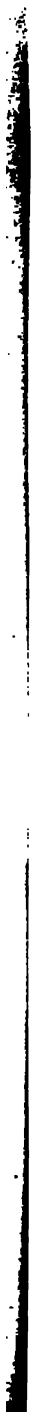
Attitudes of Granite and Quartzite.—The shape of the granite masses and the relative proportions of granite to quartzite present most important problems.

The map, page 33, gives proportions by area of granite to quartzite. From this map also are seen two apparent systems of quartzite fissures now occupied by the granite masses. There is an east-west system shown most plainly along the southern end of the Detroit claims and a north-south system branching from this and appearing also in isolated granite patches on other parts of the map.

That all the fissures of these systems are vertical, is not assumed. On the contrary there is much evidence of flat lying granite throughout the area. Above the road, near the southwest corner of the map, is a cliff exposure with granite and quartzite in horizontal layers. Near the eastern edge of the map at the end of the Mozambique claim are signs of flat granite. Here appear some large quartzite horses flat-lying, and evidently but little displaced. Again on the Chilkoot claim, a tunnel to the vein is driven under a granite roof. A winze sunk a few feet below the tunnel level cuts still another horizontal granite layer. In an opening on the Parrish, both horizontal and vertical granite may be seen. Horizontal sheets of an inch and less in thickness here are plainly branches from a large vertical mass. The thickness of these horizontal masses where they can be plainly observed is from two feet down to less than one inch. It is most probable that in places they are much over two feet in thickness.

Closely connected with the attitude of the granite masses is the attitude of the enclosing (and sometimes enclosed) quartzite. Dip is hard to make out. The layered structure of the quartzite is not always apparent. Where observed, however, in this area the dips

*See Dr. O'Hara's paper, p. 17.



are prevailing south and southeast,—away from the Harney Peak granite masses. I have also noted a few westerly dips.* Such changing dip is of course expected in so shattered a region.

The position of the quartz veins are highly inclined. Thus they appear in the Chilkoot, in the Sunrise (a claim just north of those mapped) and in two of the Detroit openings. But in another Detroit opening appears a flat lying mass of quartz about 8 inches thick.

Development.—Development has nowhere proceeded beyond 40 feet in depth. In the Chilkoot this maximum depth is obtained by driving in a side hill a 60 foot tunnel to meet the vein and then sinking at the end of this tunnel. The Detroit openings are not over 8 feet in depth. The Sunrise, just west of the area mapped has a 20 foot shaft. Thus as regards mining the country is in its infancy.

Construction of the Map.—To Mr. M. N. Bolles and to Mr. F. E. Rockwell, students of the School of Mines, belongs the credit of the construction of the map. Of the field work, the topography was mostly done by Mr. Bolles and the greater part of the geology by Mr. Rockwell. The map drawing is Mr. Bolles' work.

The topography was sketched on a skeleton of transit and stadia lines,—the fine broken lines of the map. The elevations are calculated from a U. S. Geological Survey reference stake near the southwest corner of the map.

The geology was put in first, on the evidence of outcrops, and second on that of the study of the float. The probable migration of the float and the relative amounts of the two kinds of float, granite and quartzite were both taken into account.

The value of this work to the students engaged was certainly great. It was the grasping and working out in the field of a practical problem.

*See Dr. O'Hara's paper, p. 23.

III. NOTES ON MINING OPERATIONS OUTSIDE THE AREA SURVEYED.

Gold and Lead.—It was the writer's pleasure to see, though not to study an interesting gold property about two miles east of Custer, just off the Custer-Hermosa road. This property is known as the Lizzie Lode. Its special interest lies in the character of the ore, which is blue, hard and siliceous, much resembling the blue siliceous ore of the Northern Hills. If, as now seems probable, it is the blue refractory siliceous ore of Bald Mountain, this occurrence means a great widening of the siliceous ore belt, coming, as it does here, far south on the Algonkian area.

The rich Holy Terror and Keystone mines of Keystone are perhaps the most interesting, as they are at present the most important gold mines of the Southern Hills. They demand, however, more detailed notice than can be given here, and would furnish by themselves material for another paper.

Mention can merely be made of the writer's visit to the mines and mills of these properties, when by the courtesy of Mr. J. J. Fayel, then superintendent, an underground trip was made through the Holy Terror. It is a pleasure to see mines and mills like these, well equipped and managed in a thoroughly businesslike way.

In the vicinity of Keystone are many other gold properties in various stages of development, but opportunity was not offered to carefully study any of them. The Bismarck should, however, be mentioned as at present being most actively developed. Some notes may also be given in regard to the Bullion, which besides the Holy Terror—Keystone property, was the only Keystone mine visited.

Here is found a large body of low grade ore developed by an open cut, and two tunnels with cross cuts. The open cut is in the hill crest and measures about 350 feet in length, 50 feet in width and 30 feet in depth. Below this cut, one tunnel 300 feet in length is driven into the hillside to tap the ore body at a depth of 175 feet. 200 feet from the mouth of this tunnel a cross cut



FIGURE 10. SPODUMENE CRYSTALS, ETTA TIN MINE.

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of 25 feet is made to disclose the width of the ore body. A second tunnel 320 feet in length has been driven at a lower level in order to tap the ore body at a depth of 400 feet. This tunnel requires about 300 feet more drifting to reach the ore. 230 feet from its mouth is a cross cut disclosing ore.

At Spokane an interesting visit was made to the galena mine of the Crown Hill Company. At the time of the visit, a hundred foot shaft with about eighty feet of drift to the east and twenty-five to the west was to be seen. Since then the company has sunk fifty feet in ore and foot wall. A body of ore several feet in width is reported as disclosed by this sinking. At the bottom of the shaft a water fissure appeared, delaying work until steam pumps could be introduced.

This ore is argentiferous and auriferous. It is said in regard to its silver content, to preserve the rule that the silver runs half as many ounces per ton as the per cent of lead.

The Crown Hill Company is at present making an experimental run of ore in the concentrating plant of the Glendale Tin Co., about two miles from the Spokane mine. The ore concentrated, is that of old dumps made since the beginning of the development of the mine. The concentration is made by means of a Wilfley table, and is reported as a complete success. The table separates the minerals as desired, giving three separate products, galena, iron pyrites and tailings. The capacity of the mill with only one table and inefficient rolls, is twenty tons daily.

From the Spokane mine twenty-four carloads of hand-picked high-grade galena and one carload of concentrates have been shipped.

Reports have recently been made of a new galena vein at Hayward. Much interest attaches itself to the development of the Spokane and other lead properties of the Hills, since an abundant supply of lead ore means value, not only in the lead, gold and silver which it may contain, but also in its service as a collector of the precious metals in the smelting of dry ores.

Graphite, Mica and Spodumene.—Graphite and mica

have to some extent been mined in the vicinity of Custer. The graphite has been found valuable as facing for iron founder's moulds. The mica has been used in dynamo manufacture. An occurrence of graphite was seen on French Creek where the graphite appeared in rather granular masses of varying purity up to a foot in thickness in close grained quartzite.

A mica mine about two miles west of Custer was visited. Here in a 30 foot shallow cut in pegmatite, about 40 mica books of from 8 to 12 inches in size were exposed.

A new experiment in mining in the Southern Hills has been the recent breaking down and shipment of a carload of spodumene from the famous occurrence in the Etta tin mine.

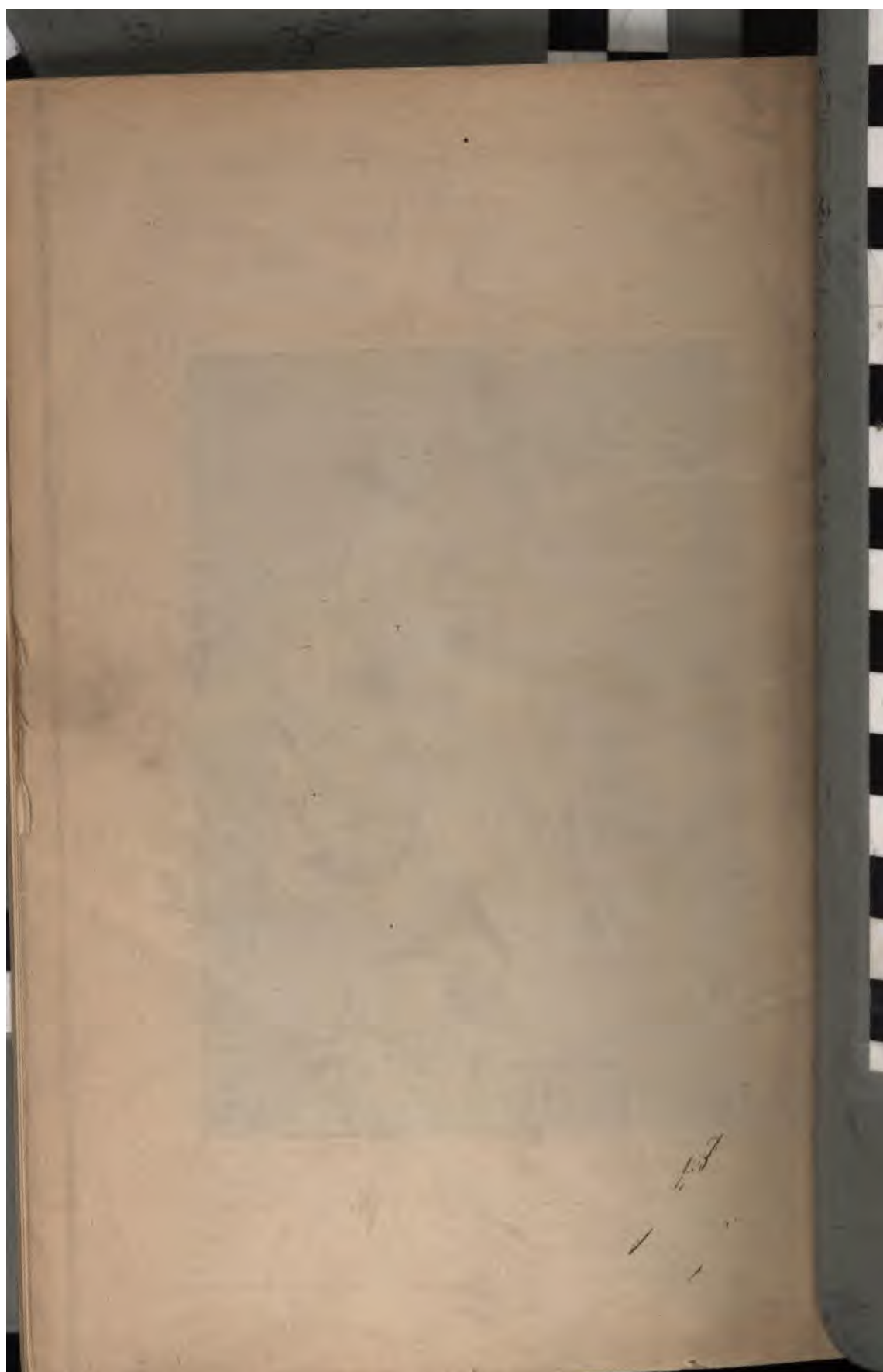
Dr. Carpenter mentions these spodumenes of the Etta in his "Mineral Resources of the Black Hills," page 136 of the "Preliminary Report of the Dakota School of Mines." He here describes their perfect shape and wonderful size, giving one a length of 35 feet. At the time of our visit none of that length were to be observed, but the accompanying half tones, (Figures 10 and 11) give some idea of the shape, size and manner of occurrence of the crystals seen by us. Unfortunately in the production of the copper plate, the man's figure which shows the scale in Figure 10 failed to come out clearly. A careful inspection will however disclose it.

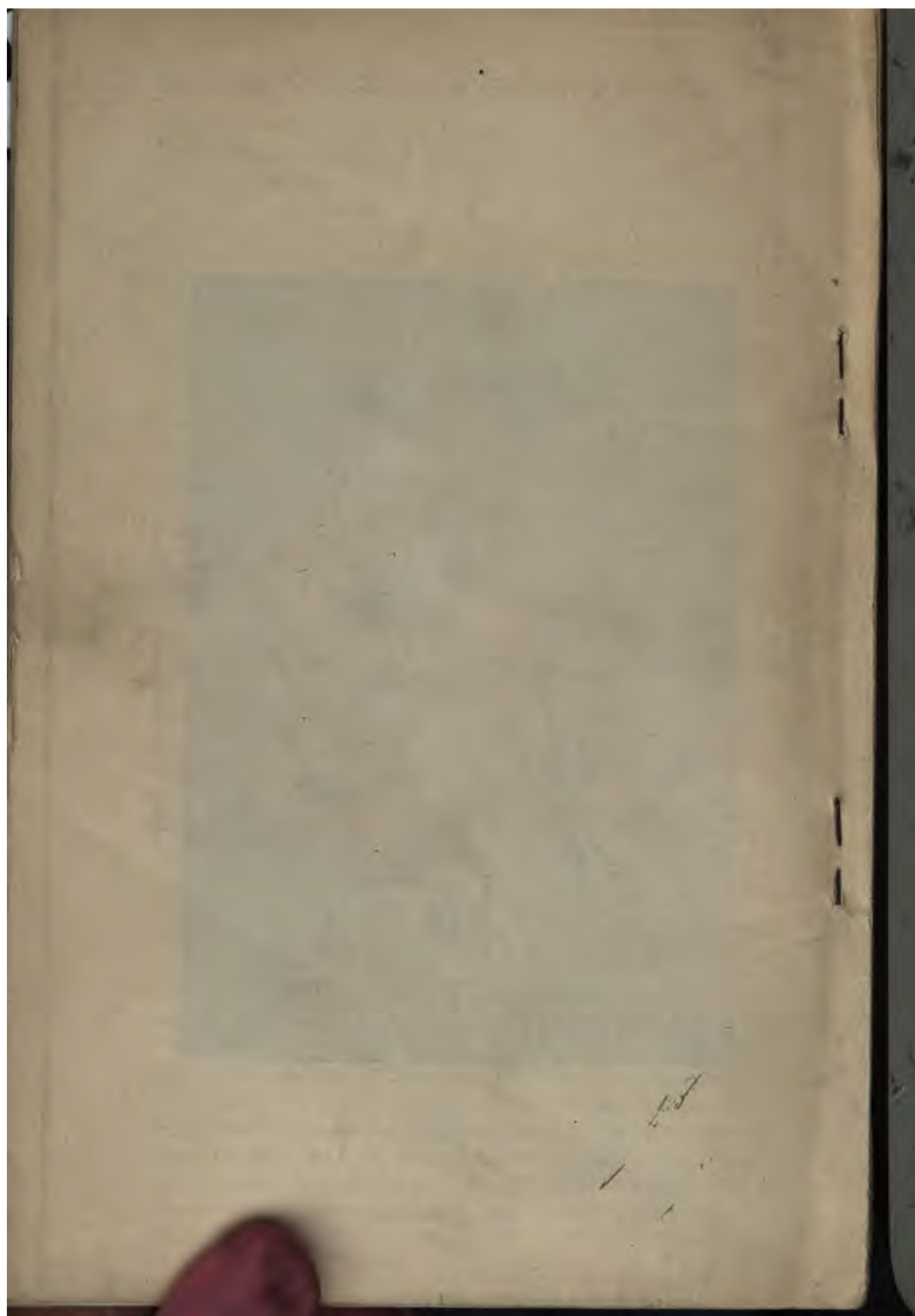
This experimental carload of spodumene was mined for Reinbold & Co. of Omaha by Mr. M. Dodge of Rapid City. Thirty tons were taken out. The mining of this material spoiled of course all those large crystals previously exposed. Fortunately our photographs were taken before the mining operations commenced.

The expenses of mining on this experimental lot were \$6.00 per ton. The spodumene proved about one-fifteenth of the material mined. The writer has as yet been unable to obtain information in regard to the chemical analysis of the material shipped, and the exact use to be made of it. He is indebted to Mr. M. Dodge for data in regard to mining and shipment.



FIGURE 11. SPODUMENE CRYSTALS, ETTA TIN MINE.





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Israel C. Russell

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BULLETIN NO. 3,

State School of Mines,

RAPID CITY, S. D.



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BULLETIN NO. 3

OF THE

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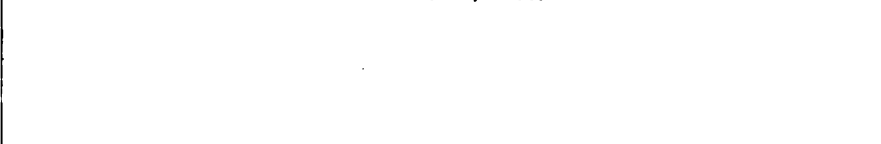
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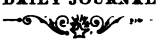
CYANIDE EXPERIMENTS.

RAPID CITY, SOUTH DAKOTA.

APRIL, 1900.






RAPID CITY DAILY JOURNAL JOB ROOMS.




Letter of Transmittal.

SOUTH DAKOTA SCHOOL OF MINES, }
RAPID CITY, April 3, 1900. }

SIR:—I have the honor to transmit herewith a paper by Prof. A. Forsyth and Mr. G. H. Clevenger on "Cyanide Experiments."

I submit it with the recommendation that it be published as Bulletin No. 3 of the School of Mines.

Respectfully,

ROBERT L. SLAGLE,
President.

HON. H. H. BLAIR,
President Regents of Education.



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CYANIDE EXPERIMENTS.*

I. The Adaptability of the Siliceous Ores of the Northern Black Hills to the Cyanide Process.

BY A. FORSYTH AND G. H. CLEVINGER.

Introduction—The object of these experiments was to show in a general way what ores of this district are adapted to the cyanide process.

The cyanide process is not, as many have supposed, a panacea for the treatment of all gold ores, as the number of failures in its practical application has fully demonstrated, but like other processes it has its field of usefulness, which must be determined in the case of each individual ore.

First, a large number of experiments on a small scale should be conducted to determine the amount of lime necessary to neutralize the cyanide consuming elements, also the percentage of extraction, size of ore and the consumption of cyanide as well as the length of time required to obtain the best results. Then, governed by these tests, which should generally be by agitation, percolation tests on a larger scale may be made.

Owing to circumstances, agitation tests were all that could be made at this time upon these ores, and they will

*This paper is the record of work performed by Mr. Clevenger during the summer of 1899. A. Forsyth, Professor of Mining and Metallurgy.

serve to show the best extraction possible under the most favorable conditions. As a rule in mill practice the extraction is somewhat lower, but the consumption of cyanide is less than in small tests.

Method of Treatment—A twenty-one assay ton sample of each ore was ground to pass a thirty mesh screen, and was divided into seven equal parts of three assay tons each. One part was ground to pass an eighty mesh screen and then assayed. The other six were placed in glass stoppered bottles with the requisite amount of lime.

The amount of lime required was determined by taking a ten-gram sample of the ore and adding ten cubic centimeters of a decinormal solution of potassium hydroxide and then titrating the excess of alkali with decinormal sulphuric acid. Then by a simple calculation the amount of lime necessary to counteract the cyanide consuming elements was ascertained.

Two samples were treated with a 0.50 per cent solution, two with a 0.25 per cent solution and two with a 0.10 per cent solution of cyanide. The same weight of solution as ore was used in each case. The samples were placed in an agitator. Three were agitated twenty-four hours, and three forty-eight hours. This gave a considerable range as regards strength of solution and time of treatment. The contents of each bottle was filtered and the residue assayed and the percentage of extraction of the precious metals calculated. The solutions were tested for the consumption of cyanide by titrating with a solution of silver nitrate, one cubic centimeter of which equaled one pound of cyanide per ton of solution when a ten cubic centimeter sample was taken for titration.*

*For further information concerning laboratory work in connection with the Cyanide Process the reader is referred to Furman's Manual of Assaying; Notes on the Cyanide Process, Bosqui; The Cyanide Process, Park; The Cyanide Process, Scheidel and Rose's Metallurgy of Gold.

View of
AGITATOR
FOR
CYANIDE TESTS.

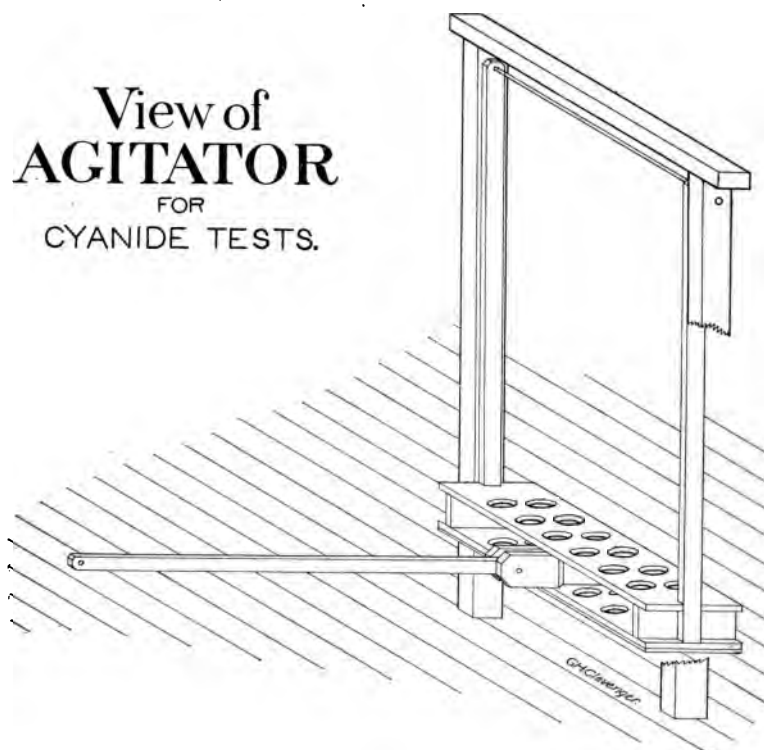


FIG. 1.

NOTE—The scale of the drawing is about one inch to one foot. The arm is connected with a crank having about a 5-inch throw.

By regulating the speed of the crank shaft, any degree of agitation from a gentle mixing to a violent shaking can be obtained. The samples to be tested may be placed in small glass fruit jars with glass tops fastened by spring clamps. The jars can be secured in the machine by wooden wedges.

Ten ores in all were experimented upon with the following results:

No. 1.

Trojan. (Blue Ore).

Character of Ore—A typical blue ore from the upper contact,** showing pyrite and fluorite, very dense and compact.

Lime—One ton of ore requires 4.6 pounds of lime.

ASSAY:—

Gold, 0.40 oz.	Silver, 1.96 oz.
or Gold, \$8.00 §	Silver, \$1.18

TWENTY-FOUR HOUR TREATMENT.

Number,	1	2	3
Strength of solution (per cent),	0.50	0.25	0.10
Pounds of cyanide consumed per ton,	2.0	1.7	1.5
Percentage of gold extracted,	47.5	42.5	47.5
Percentage of silver extracted,	50.0	41.8	20.4

FORTY-EIGHT HOUR TREATMENT.

Number,	1	2	3
Strength of solution (per cent),	0.50	0.25	0.10
Pounds of cyanide consumed per ton,	2.9	2.3	2.7
Percentage of gold extracted,	42.5	45.0	40.0
Percentage of silver extracted,	40.3	38.3	4.5

It will be seen that the best extraction in the case of this ore is obtained with a 0.50 per cent solution in twenty-four hours, the extraction with the same strength of solution and under the same conditions, but with the ore treated for a period of forty-eight hours, is 5.0 per cent lower in the case of the gold, and 9.7 per cent lower in the case of the silver.

A three assay ton sample of this ore was given a dead roast and the amount of lime required then determined and

**The siliceous gold ores of the Northern Black Hills are found in the Cambro-Silurian rocks in the two principal horizons or contacts, the upper or shale contact and the lower or quartzite contact.

§Gold is calculated at \$20.00 per ounce, and silver at \$60.60 per ounce throughout this article.

added. Then two hundred cubic centimeters of a 0.50 per cent cyanide solution were added and the whole agitated for forty-eight hours. Then the solution was tested for the consumption of cyanide and the residues assayed. Thus the percentage of extraction and the consumption of cyanide were calculated.

Pounds cyanide consumed per ton,	0.8
Percentage of gold extracted,	87.5
Percentage of silver extracted,	17.5

Thus it will be seen that by giving this ore a dead roast not only is the percentage of extraction increased but the consumption of cyanide is also decreased.

The consumption of cyanide by a roasted ore depends largely upon the way it is roasted. If the ore is incompletely roasted, soluble sulphates, arseniates, etc., will be formed. These will decompose the cyanide and thus a higher consumption of cyanide will result than with the raw ore. While if all the elements of the ore are completely oxidized the solutions will suffer no decomposition from this cause and the consumption of cyanide will be much less than with the raw ore.

NO. 2.

Trojan. (Blue Ore).

Character of Ore—A typical blue ore from the upper contact, showing pyrite and fluorite, very dense and compact.

Lime—One ton requires 6.0 pounds of lime.

ASSAY:—

Gold, 1.42 oz.	Silver, 2.98 oz.
or Gold, \$28.40	Silver, \$1.79

TWENTY-FOUR HOUR TREATMENT.

Number,	1	2	3
Strength of solution (per cent),	0.50	0.25	0.10
Pounds of cyanide consumed per ton,	3.3	3.2	—*
Percentage of gold extracted,	59.0	56.3	—
Percentage of silver extracted,	48.6	41.6	—

*Lost by bottles breaking while being agitated.

FORTY-EIGHT HOUR TREATMENT.

Number,	1	2	3
Strength of solution (per cent),	0.50	0.25	0.10
Pounds of cyanide consumed per ton,	3.6	—*	all
Percentage of gold extracted,	62.7	58.5	35.9
Percentage of silver extracted,	51.7	37.8	0.0

No. 3.

Trojan. (Light Brown).

Character of Ore—The ore comes from the same mine as the two preceding samples of blue ore. It is well oxidized but not very porous.

Lime—One ton of ore requires 2.6 pounds of lime.

ASSAY—

Gold, 0.25 oz. Silver, 2.43 oz.
or Gold, \$5.00 Silver, \$1.46

TWENTY-FOUR HOUR TREATMENT.

Number,	1	2	3
Strength of solution (per cent),	0.50	0.25	0.10
Pounds of cyanide consumed per ton,	0.7	0.4	0.4
Percentage of gold extracted,	92.0	96.0	92.0
Percentage of silver extracted,	34.9	28.8	23.0

FORTY-EIGHT HOUR TREATMENT.

Number,	1	2	3
Strength of solution (per cent),	0.50	0.25	0.10
Pounds of cyanide consumed per ton,	1.2	0.5	0.5
Percentage of gold extracted,	96.0	96.0	96.0
Percentage of silver extracted,	26.7	29.6	34.5

No. 4.

Trojan. (Dark Brown.)

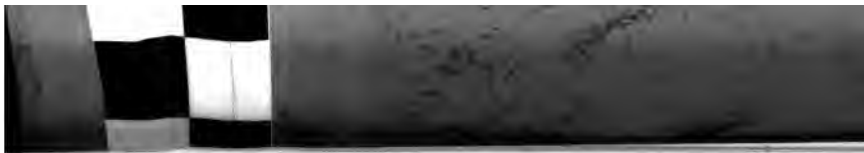
Character of Ore—A well oxidized ore, from the same mine as the above, differing only in being more highly mineralized and of a higher grade.

Lime—One ton of ore requires 3.0 pounds of lime.

ASSAY—

Gold, 1.27 oz. Silver, 3.93 oz.
or Gold, \$25.40 Silver \$2.36

*Lost by bottles breaking while being agitated.



TWENTY-FOUR HOUR TREATMENT.

Number,	1	2	3
Strength of solution (per cent),	0.50	0.25	0.10
Pounds of cyanide consumed per ton,	0.9	0.7	0.4
Percentage of gold extracted,	78.7	75.6	64.0
Percentage of silver extracted,	26.2	24.2	17.8

FORTY-EIGHT HOUR TREATMENT.

Number,	1	2	3
Strength of solution (per cent),	0.50	0.25	0.10
Pounds of cyanide consumed per ton,	1.2	0.9	0.6
Percentage of gold extracted,	70.0	72.4	79.5
Percentage of silver extracted,	36.1	49.6	45.0

No. 5.

Decorah-Dividend. (Rim Rock).

Character of Ore - A dark colored clayey gouge coming from the lower contact.

Lime One ton of ore requires 6.0 pounds of lime.

ASSAY—

Gold, 0.82 oz.	Silver, 0.93 oz.
or Gold, \$16 40	Silver, \$0.56

TWENTY-FOUR HOUR TREATMENT.

Number,	1	2	3
Strength of solution, (per cent),	0.50	0.25	0.10
Pounds cyanide consumed per ton,	0.8	0.3	0.2
Percentage of gold extracted,	73.0	75.6	75.6
Percentage of silver extracted,	26.8	0.0	0.0

FORTY-EIGHT HOUR TREATMENT.

Number,	1	2	3
Strength of solution, (per cent),	0.50	0.25	0.10
Pounds of cyanide consumed per ton,	0.7	0.7	0.2
Percentage of gold extracted,	81.7	78.0	78.0
Percentage of silver extracted,	27.8	12.9	20.4

This ore would be difficult to treat commercially, owing to its clayey nature, the clay holding gold bearing solution, which it is almost impossible to displace by wash water.

No. 6.

Decorah-Dividend. (Yellow Sand).

Character of Ore—A loose yellow sand containing fragments of white quartz. Comes from the Algonkian, just below the Cambrian ore horizon.

Lime—One ton of ore requires 4.0 pounds of lime.

ASSAY—

Gold, 0.27 oz. Silver, 0.87 oz.
or Gold, \$5.40 Silver, \$0.52

TWENTY-FOUR HOUR TREATMENT.

Number,	1	2	3
Strength of solution, (per cent),	0.50	0.25	0.10
Pounds of cyanide per ton,	0.7	0.5	0.3
Percentage of gold extracted,	55.5	55.5	55.5
Percentage of silver extracted,	27.5	8.0	12.6

FORTY-EIGHT HOUR TREATMENT.

Number,	1	2	3
Strength of solution, (per cent),	0.50	0.25	0.10
Pounds of cyanide consumed per ton,	1.2	0.8	0.5
Percentage of gold extracted,	63.0	63.0	70.3
Percentage of silver extracted	12.6	9.2	39.0

No. 7.

Decorah-Dividend (Shale Ore).

Character of Ore A mineralized shale from the lower contact containing values in gold and silver. Completely oxidized.

Lime—One ton of ore requires 5.0 pounds of lime.

ASSAY—

Gold, 0.63 oz. Silver, 0.51 oz.
or Gold, \$12.60 Silver, \$0.31

TWENTY-FOUR HOUR TREATMENT.

Number,	1	2	3
Strength of solution, (per cent),	0.50	0.25	0.10
Pounds of cyanide consumed per ton,	1.1	0.6	0.4
Percentage of gold extracted,	88.8	87.2	85.7
Percentage of silver extracted,	0.0	5.8	0.0



FORTY-EIGHT HOUR TREATMENT.

Number,	1	2	3
Strength of solution, (per cent),	0.50	0.25	0.10
Pounds of cyanide consumed per ton,	1.2	0.7	0.5
Percentage of gold extracted,	90.4	92.0	88.8
Percentage of silver extracted,	0.0	0.0	0.0

No. 8.

Decorah-Dividend (Mahoney Stope).

Character of Ore—A highly siliceous ore from the lower contact, well oxidized. Shows no pyrite or other heavy minerals.

Lime—One ton of ore requires 2.25 pounds of lime.

ASSAY—

Gold, 4.33 oz.	Silver, 1.80 oz.
or Gold, \$86.60	Silver, \$1.08

TWENTY-FOUR HOUR TREATMENT.

Number,	1	2	3
Strength of solution (per cent),	0.50	0.25	0.10
Pounds of cyanide consumed per ton,	0.8	0.7	0.5
Percentage of gold extracted,	83.3	84.7	82.6
Percentage of silver extracted,	39.4	45.0	34.4

FORTY-EIGHT HOUR TREATMENT.

Number,	1	2	3
Strength of solution (per cent),	0.50	0.25	0.10
Pounds of cyanide consumed per ton,	1.8	0.8	0.5
Percentage of gold extracted,	85.6	85.6	82.4
Percentage of silver extracted,	34.4	33.8	34.4

While the percentage of extraction indicated above might be satisfactory in the case of an ore of lower grade, it is far from satisfactory on this grade of ore.

No. 9.

Two Johns Mining Co.

Character of Ore—A well oxidized ore, very porous, from the Squaw Creek district.

Lime—One ton of ore requires 4.3 pounds of lime.

ASSAY—

Gold, 1.29 oz.	Silver, 1.26 oz.
or Gold, \$25.80	Silver, \$0.76



TWENTY-FOUR HOUR TREATMENT.

Number,	1	2	3
Strength of solution (per cent),	0.50	0.25	0.10
Pounds of cyanide consumed per ton,	1.8	0.8	0.5
Percentage of gold extracted,	87.6	86.0	94.9*
Percentage of silver extracted,	25.4	35.7	39.3

FORTY-EIGHT HOUR TREATMENT.

Number,	1	2	3
Strength of solution (per cent),	0.50	0.25	0.10
Pounds of cyanide consumed per ton	0.4	0.3	0.3
Percentage of gold extracted,	89.1	88.4	86.8
Percentage of silver extracted,	20.6	18.3	13.5

No. 10.

Ulster. (Ragged Top).

Character of Ore—A flint showing fluorite and a slight incrustation of lime, but does not show any pyrite or other heavy minerals. In fact a typical ore of the Ragged Top district.

Lime—One ton of ore requires 3.0 pounds of lime.

ASSAY—

Gold, 8.78 oz. Silver, 0.97 oz.
or Gold, \$175.60 Silver, \$0.58

FORTY-EIGHT HOUR TREATMENT.

Number,	1	2	3
Strength of solution (per cent),	0.50	0.25	0.10
Pounds of cyanide consumed per ton,	0.3	0.5	—†
Percentage of gold extracted,	88.4	88.6	—†
Percentage of silver extracted,	0.0	13.4	—†

*Probably too high owing to an error in sampling or assaying.

†Lost by breaking in agitator.

Table A.

The following table gives a brief summary of the best percentage of extraction, time, pounds cyanide consumed per ton and pounds lime used per ton in the case of each ore:

ORE.		Assay Ounces.	Strength of Solution, per cent.	Time, hours	Lbs. lime used per ton.	Lbs. cyan- ide con'd per ton.	Per Cent of Extra'n
Upper Contact, Bald Mountain District.	Trojan (Blue Ore)	Gold	.40	10 &	24	4.6	2.0 &
		Silver	1.96	.50	24	4.6	1.5
	Trojan (Blue Ore Roasted.)	Gold	.40	.50	48	5.0	0.8
		Silver	1.96	.50	48	5.0	0.8
	Trojan (Blue Ore)	Gold	1.42	.50	48	6.0	3.6
		Silver	2.98	.50	48	6.0	3.6
	Trojan (Lt Brown)	Gold	.25	.50	24	2.6	1.2
		Silver	2.43	.25 & 10	48	0.5 & 0.4	96.0
	Trojan (Dk Br'wn)	Gold	1.27	.50	24	2.6	0.7
		Silver	3.93	.50	24	2.6	0.7
Lower Contact, Bald Mountain District.	Decorah-Divid'nd (Kimrock.)	Gold	.82	.10	48	6.0	0.7
		Silver	.93	.50	48	6.0	0.7
	Decorah-Divid'nd (Yellow Sand)	Gold	.27	.10	48	4.0	0.5
		Silver	.87	.10	48	4.0	0.5
	Decorah-Divid'nd (Shale Ore)	Gold	.63	.25	48	5.0	0.7
		Silver	.51	.25	24	5.0	0.6
	Decorah-Divid'nd (Mahoney Stope)	Gold	4.33	.50 &	48	2.25	1.8
		Silver	1.80	.25	24	2.25	0.8
Ragged Top Squaw Creek District.	Two Johns	Gold	1.29	.50	48	4.3	0.4
		Silver	1.26	.25	24	4.3	0.3
	Ulster	Gold	8.78	.25	48	3.0	0.5
		Silver	.97	.25	48	3.0	0.5

II. The Cyanide Process as Applied to Chlorination Tailings.††

Chemically tailings from the chlorination process form an ideal material for treatment by the cyanide process. Before chlorination the ore is given a dead roast, which removes most of the sulphur, arsenic and tellurium. Then the subsequent treatment with chlorine, and the complete washing remove all metallic elements which would consume cyanide. The complete washing also removes all the free acid introduced during chlorination.

The following results were obtained from tailings from the chlorination plant at Rapid City. While the extraction was not high, the small consumption of cyanide is remarkable. The treatment consisted of contact with occasional agitation with solutions of 1.0 per cent, 0.75 per cent, 0.50 per cent, 0.40 per cent, 0.30 per cent, 0.25 per cent, 0.15 per cent, 0.10 per cent and 0.05 per cent, for periods of 24, 48 and 168 hours.

The amount of lime required was determined as in the case of the siliceous ores. Five pounds per ton of tailings were used. The tailings assayed—

Gold, 0.26 oz.	Silver, 1.64 oz.
or Gold, \$5.20	Silver, \$0.98

The following tables show the percentage of extraction and consumption of cyanide under the various conditions of treatment:

††The writers are indebted to Mr. A. S. Halley for assistance rendered in connection with this division of this paper

TWENTY-FOUR HOUR TREATMENT.

Number, — —	1	2	3	4	5	6	7	8	9	10
Strength of solution, (per cent), — —	1.0	0.75	0.50	0.40	0.30	0.25	0.20	0.15	0.10	0.05
Pounds of cyanide consumed per ton, —	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Percentage of gold extracted, — —	30.7	30.7	42.3	42.4	30.7	34.6	38.4	30.7	42.3	34.6

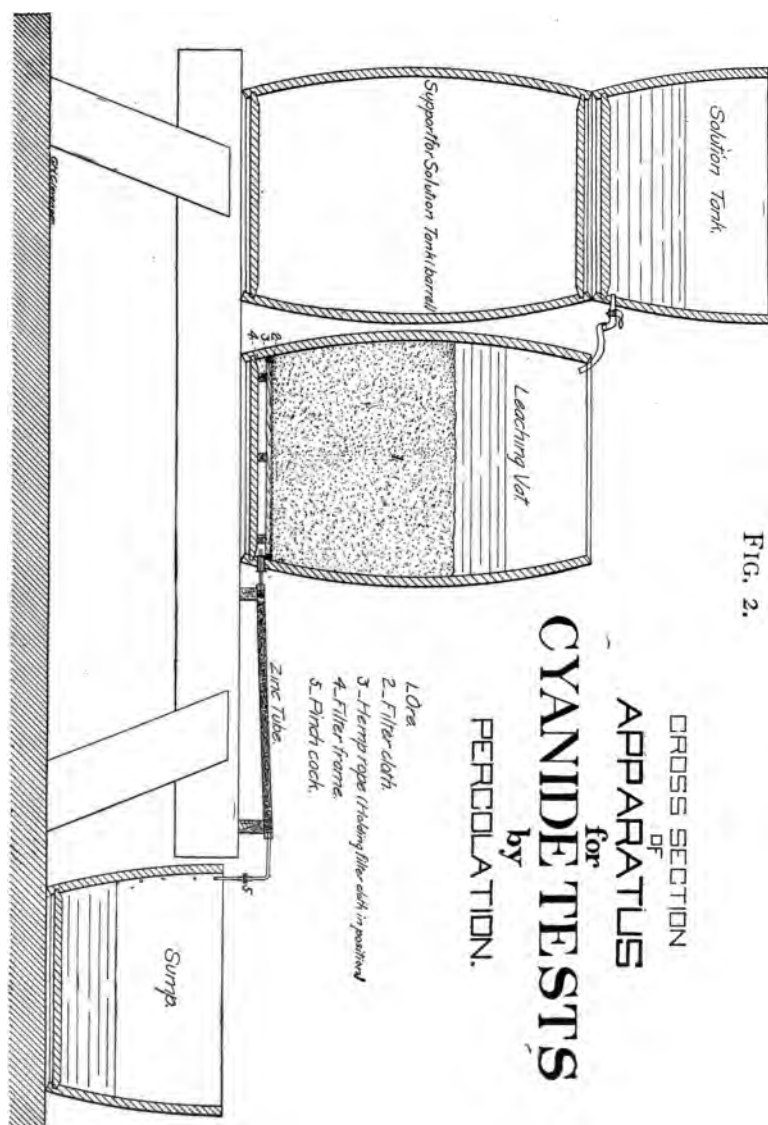
FORTY-EIGHT HOUR TREATMENT.

Number, — —	1	2	3	4	5	6	7	8	9	10
Strength of solution, (per cent), — —	1.0	0.75	0.50	0.40	0.30	0.25	0.20	0.15	0.10	0.05
Pounds of cyanide consumed, per ton, —	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Percentage of gold extracted, — —	38.4	34.6	42.3	42.3	42.3	42.3	42.3	50.0	38.4	42.3

ONE HUNDRED AND SIXTY-EIGHT HOUR TREATMENT.*

Number, — —	1	2	3	4	5	6	7	8	9	10
Strength of solution, (per cent), — —	1.0	0.75	0.50	0.40	0.30	0.25	0.20	0.15	0.10	0.05
Pounds of cyanide consumed per ton, —	1.0	0.6	0.6	0.2	0.2	0.2	0.2	0.2	0.1	0.1
Percentage of gold extracted, — —	46.2	46.2	46.2	50.0	50.0	34.2	34.2	46.2	46.2	53.8

*The consumption in this case is largely due to the decomposition of the solutions by air and light.



A sizing test was made to ascertain whether the gold was in the coarse or fine material, and also which size gave the best extraction.

21	per cent	passed	50 mesh—Assay,	Gold,	0.19 oz.
20	"	"	30-50 " — "	"	0.26 "
30	"	"	20-30 " — "	"	0.29 "
29	"	"	10-20 " — "	"	0.36 "

Thus it will be seen that the higher value is in the coarser material.

A two pound sample was treated by percolation for a period of seventy-two hours with a 0.15 per cent of cyanide. The tailings from this test were sized, assayed and the percentage of extraction from each size computed.

Per cent of gold extracted from	50 mesh and under,	47.4
"	" 30-50 "	46.2
"	" 20-30 "	37.9
"	" from over 20 "	50.0

Guided by the preceding experiments, tests by percolation upon samples of two hundred pounds were made, the gold being precipitated from the solution by means of zinc shavings.

Test No. 1.

ASSAY—

Gold, 0.26 oz.	Silver, 1.64 oz.
or Gold, \$5.20	Silver, \$0.98

Lime—One half pound of lime was mixed with the tailings while charging.

Treatment—One hundred and fifty pounds of cyanide solution containing 2.1 lbs. cyanide per ton (0.105 per cent)

NOTE—As can be seen from the drawing (Fig. 2) the solution tank, leaching vat and sump, as well as the support for the solution tank are made of barrels. The solution tank and sump are made from one barrel by sawing it in two. The filter frame is simply thin slats nailed to cross pieces. For a filter cloth a piece of burlap or canvas can be used. The zinc tube is a one-inch glass tube about two feet long. The filter frame and the inside of the solution tank, leaching vat and sump are given a coat of asphalt before using.

were run upon the charge and allowed to soak two hours. The solution was then allowed to percolate forty hours. The same solution was replaced upon the charge and allowed to percolate thirty-two hours. The charge was then washed with water for two hours. All solutions, including the wash water, were run through a glass tube containing freshly turned zinc shavings. After treatment, the solution was tested for the consumption of cyanide and it was found that .041 lbs. cyanide had been consumed, or 0.41 lbs. per ton of tailings treated.

CLEAN UP OF ZINC TUBE—

Gold, 0.4175 grams.
 Silver, 0.577 grams.
 Percentage of gold extracted, 51.3
 Percentage of silver extracted, 11.3

Method of Cleaning up Zinc Tube.—

The contents of the tube were washed into a large beaker and dilute hydrochloric acid added until all action ceased. The beaker was then heated and the solution filtered. The filter paper together with the residue was placed in a scorifier with test lead and scorified, the resulting button being cupelled, parted and weighed.

ASSAY OF TAILINGS—

Gold, 0.13 oz. Silver, 1.51 oz.
 or Gold, \$2.60 Silver, \$0.91

Percentage of extraction as shown by the assay of the tailings:

Gold, 50.0 per cent.
 Silver, 7.9 “

ASSAY OF SUMP SOLUTION—

Gold, trace. Silver, trace.

Test No. 2.

ASSAY—

Gold, 0.30 oz. Silver, 1.34 oz.
 or Gold, \$6.00 Silver, \$1.16

Lime—Three-fifths of a pound of lime was mixed with the tailings while being charged.

Treatment—One hundred and fifty pounds of solution, containing 1.1 pounds cyanide per ton (0.0505 per cent) were run upon the charge and allowed to soak for two hours, then percolate eighteen hours. Then the same solution was replaced upon the charge and allowed to percolate twenty-five hours.

The consumption of cyanide in this case was 0.16 lbs. per ton of tailings treated. The cyanide in the wash water is accounted for, thus the low consumption.

CLEAN UP OF ZINC TUBE—

Gold, 0.4005 grams.
Silver, 0.5725 grams.
Percentage of extraction, gold, 42.6
Percentage of extraction, silver, 8.34

ASSAY OF TAILINGS—

Gold, 0.16 oz. Silver, 1.56 oz.
Percentage of extraction as shown by the assay of the tailings:

Gold, 46.6
Silver, 19.5

ASSAY OF SUMP SOLUTION—

Gold, 0.055 oz.
Per cent of gold precipitated by zinc, 97.04

The percentage of extraction as indicated by the assays and the clean up of the zinc tube do not correspond. This is likely due to the errors in sampling although all precautions were taken to obtain an average sample in each case.

III. The Determination of Gold in Cyanide Solutions.

The older works in chemistry give evaporation to dryness as the only means of completely recovering gold from cyanide solutions. They also mention that zinc will to a certain extent precipitate the gold.

After the development of the cyanide process, some means for the determination of gold in the cyanide solutions was required. The first method employed was to evaporate some multiple of an assay ton of solution upon a tray made of lead foil. This was then scorified, cupelled, parted and weighed in the usual way. When the solution contained no base metals, the lead tray was cupelled direct. Later larger samples of several assay tons were evaporated to dryness with litharge. This was then mixed with soda, silica and argol, placed in a crucible and melted down. The resulting lead button was then cupelled, parted and weighed. This method has the advantage of treating a larger sample of solution, but loss is almost certain to follow, due to splattering and sticking to the dish, unless the latter part of the evaporation is carried on upon a water bath, which is necessarily slow.

Professor Christy, of the University of California, after a great deal of experimentation, found that copper sulphide, boiled with an acidulated cyanide solution would completely precipitate all the gold and silver in the solution.** Based on this discovery, the following method of determining gold from cyanide solutions has been suggested.

Ten assay tons* are placed in a No. 5 beaker and boiled. Then sulphuric acid is added until the solution is distinctly

**Trans, Am. Inst. Min. Eng., Vol. XXVI, p. 735.

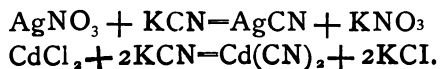
*Thirty cubic centimeters equal approximately one assay ton.

acid; then 0.3 gram copper sulphate is added, and as soon as dissolved, sodium sulphide is added until all the copper is precipitated. The contents of the beaker are then slowly boiled for one half hour. The solution is filtered and the filter paper together with the precipitate is placed in a scorifier with test lead and scorified. The resulting button of lead is cupelled, parted and weighed. This method gives as good results as the evaporation of the solution with litharge and is much quicker and more easily handled. The solution filters very rapidly, while in the case of evaporation with litharge much annoyance is caused by the litharge sticking to the dish in which the evaporation is done.

Instead of using sodium sulphide to precipitate the copper as a sulphide, hydrogen sulphide was tried. This worked in every particular as well as the sodium sulphide, and in many respects is preferable. Lead acetate was then substituted for copper sulphate but after repeated trials it was found that a small portion of the gold remained unprecipitated. Cadmium chloride was now tried in place of the copper sulphate, but in an acidulated solution with hydrogen sulphide, although the cadmium was precipitated as a sulphide, no gold came down with it. On adding cadmium chloride to a cyanide solution which had not been acidulated, a white precipitate was noticed, which was filtered out and scorified with test lead. This proved to have precipitated most of the gold in the solution.

Silver nitrate, as stated by Christy, completely precipitates gold from cyanide solutions, but it is barred as a reagent for this purpose owing to its cost.

Cadmium salts like silver salts react with potassium cyanide.



The following tables will show the comparison of the various methods:

Method Employed.	Oz. Gold Re- covered per ton.	Remarks.
SERIES 1.*		
Evaporated on lead tray....	1.110	Low due to splattering. Sodium sulphide used to precipitate the copper.
Evaporated with litharge....	0.906	
Copper sulphide.....	1.148	
SERIES 2.		
Evaporation on lead tray....	0.240	Latter part of evapora- tion carried on upon a water bath, hence no splat- tering. Hydrogen sulphide used to precipitate the copper.
Evaporation with litharge...	0.265	
Copper sulphide.....	0.267	
SERIES 3.		
Copper sulphide.....	0.225	Acidulated with nitric acid. Acidulated with hydro- chloric acid Acidulated with acetic acid.
Lead sulphide.....	0.000	
Lead sulphide.....	0.208	
Lead sulphide.....	0.200	
SERIES 4.		
Evaporation with litharge...	1.369	Acidulated with hydro- chloric acid, Acidulated with acetic acid. Acidulated with sulphur- ic acid. Solution alkaline.
Copper sulphide.....	1.367	
Lead sulphide.....	1.198	
Lead sulphide.....	0.88	
Cadinum sulphide....	0.000	
Cadinum chloride.....	1.207	

*Solutions of different gold values were used in each series. The high-
est figures of gold recovery in each series may be taken as the true gold
content of the solution used in that series.



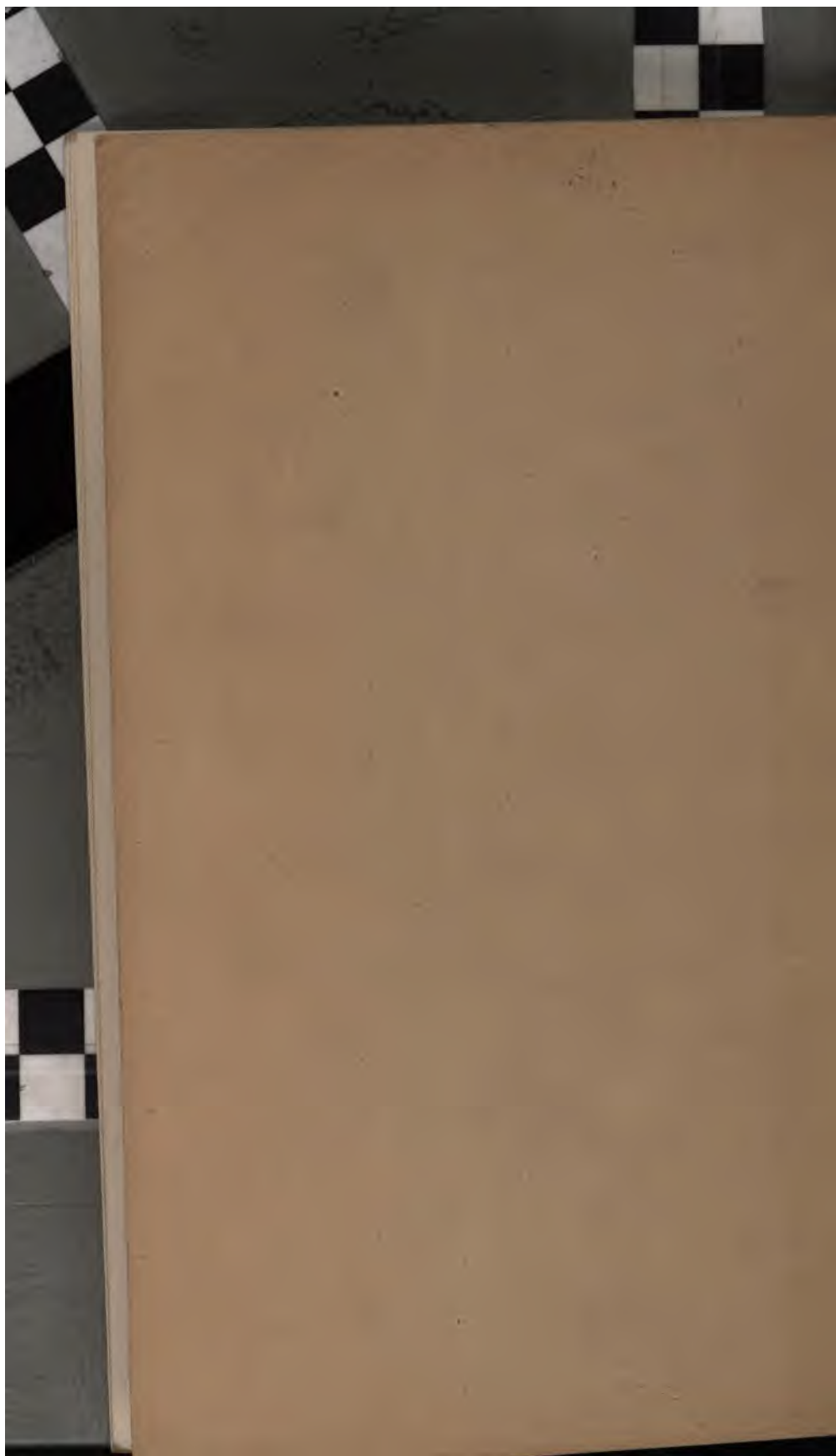


Table.

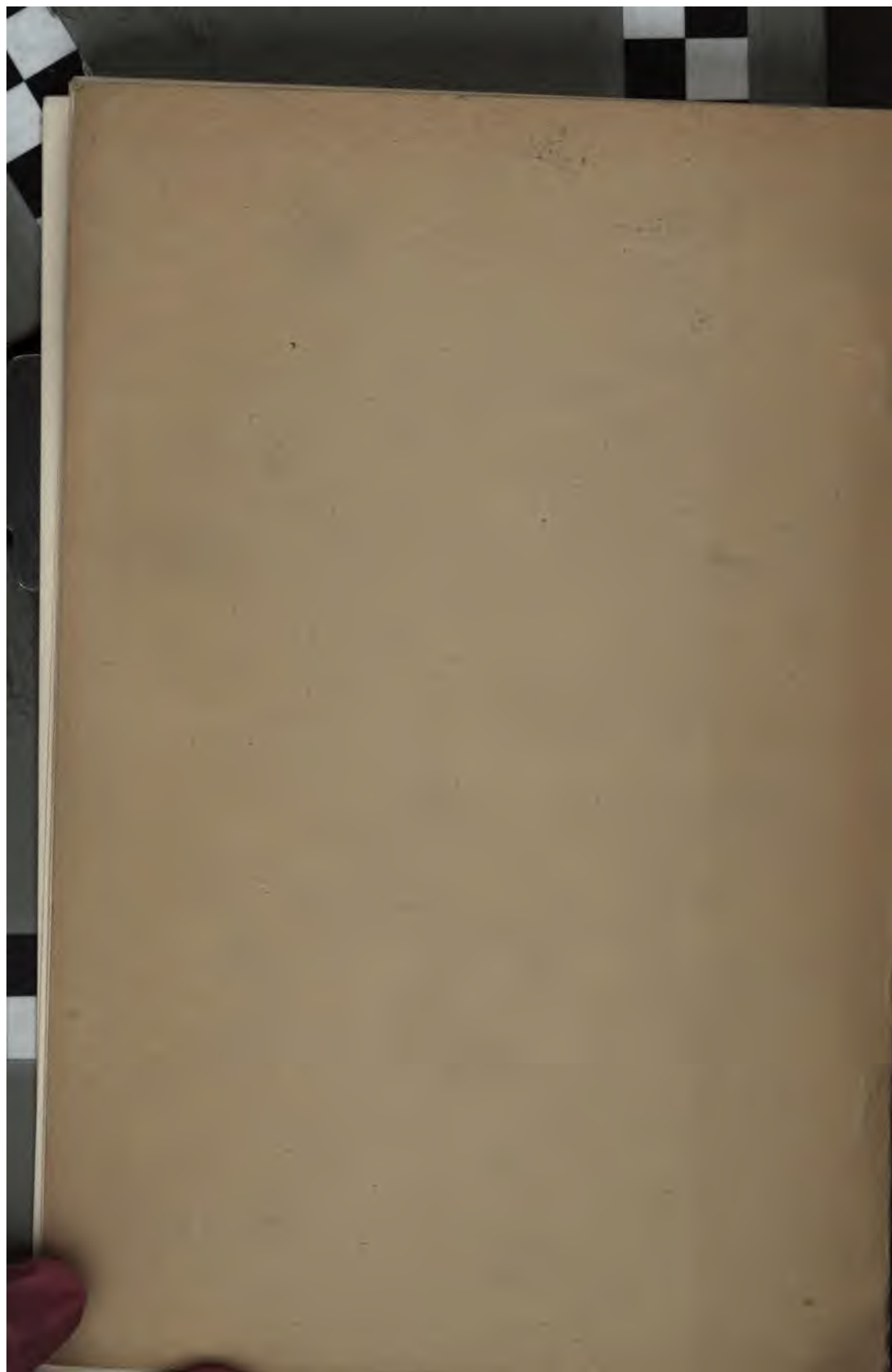
Material.	Size.	Amt. of solu- tion.	Gold in the original so- lution.	Cyanide in the origi- nal solu- tion	Gold in solution at end of exp'm't	Cyanide in so- lution at the end of the ex- periment.	Percentage of gold lost	Percentage of cyanide lost.
Wood (plain pine)....	7/8"x2"x6"	450 c.c.	1.20 oz per ton	2.4 lb. per ton	1.015 oz.	1.8 lbs. per ton.	15.4	25.0
Wood, (coated with asphalt.) ...	7/8"x2"x6"	450 c.c.	1.20 oz per ton	2.4 lb. per ton	1.128 oz.	2.1 lbs. per ton.	6.0	12.5
Burlap (12 ounce)...	8"x24"	350 c.c.	1.20 oz per ton	2.4 lb. per ton	0.776 oz.	0.8 lbs. per ton.	35.3	66.6
Iron (nails	Nine 10 penny nails.	150 c.c.	1.20 oz per ton	2.4 lb. per ton	1.200 oz.	2.2 lbs. per ton.	0.0	8.3

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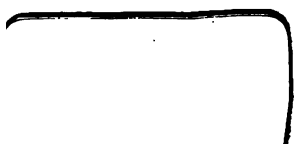
OF THE

SOUTH DAKOTA SCHOOL OF MINES

DEPARTMENT OF GEOLOGY.

RAPID CITY, SOUTH DAKOTA.

APRIL, 1900.



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RAPID CITY DAILY JOURNAL JOB ROOMS.


Letter of Transmittal.

SOUTH DAKOTA SCHOOL OF MINES, }
RAPID CITY, April 4, 1900. }

SIR: I have the honor to transmit herewith a paper by Dr. Cleophas C. O'Harra on "A History of the Early Explorations and of the Progress of Geological Investigation in the Black Hills Region," and also one on "A Bibliography of Contributions to the Geology and Geography of the Black Hills region."

I submit them with the recommendation that they be published as Bulletin No. 4 of the School of Mines.

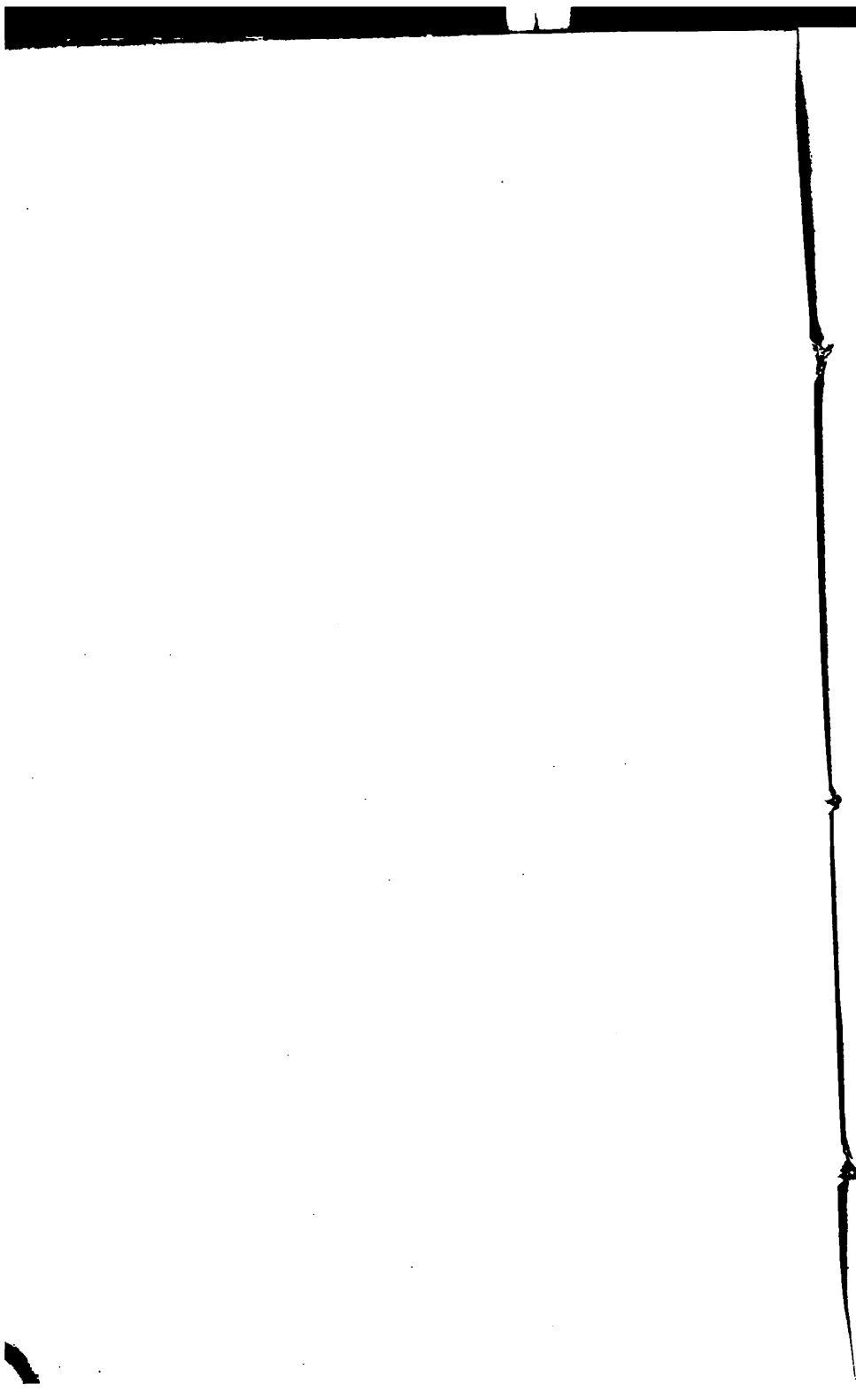
Respectfully,

ROBERT. L. SLAGLE,
President.

HON. H. H. BLAIR,
President Regents of Education.

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A HISTORY

Of the Early Explorations and of the Progress of Geological Investigation in the Black Hills Region.*

BY CLEOPHAS C. O'HARRA.

Our knowledge of the Black Hills dates from near the beginning of the present century. The development of that knowledge, particularly as related to geology, may be conveniently divided into three periods, viz.: the period of fur-trading exploration; the period of military and geographical exploration; and the period of geological exploration. The first includes the early half of the century and is almost barren of scientific results. The second includes approximately the third quarter of the century beginning with the exploration by Dr. Evans in 1849, and closing with the military expedition under the command of Lieutenant-Colonel G. A. Custer in 1874. Several of the expeditions sent to the region during this period were accompanied by one or more geologists or topographers and in this way scientific information of much value was obtained. The third period begins with the Newton-Jenney survey in 1875 and extends to the present time. The Stanton military expedition was made later than this and indeed the Newton-Jenney survey was in the form of a military expedition, but since the explicit purpose of the latter was to investigate the geology and mineral resources of the region, which work was carefully and comprehensively done, the expedition may be fitly considered as marking the beginning of a distinct period.

The pioneer explorers of the northwest, Lewis and Clarke,

*A part of this paper was given as an address before the South Dakota Educational Association at its meeting in Hot Springs, August 3, 1899.

who made their famous exploratory trip to the mouth of the Columbia river during the years 1804-05-06, are credited with the first scientific mention of the Black Hills. The original map accompanying the report of this expedition represents the Black Hills as a single narrow mountain ridge extending from the South Fork of the Cheyenne river northwestward beyond the North Fork to the lower waters of Tongue river [Powder river?]. The report states that "Mr. Valle, a French trader, has ascended the Cheyenne for a distance of 300 leagues and reports that the Black Mountains are very high, covered with great quantities of pine and in some parts the snow remains during the summer." It may be well to state for the benefit of those not acquainted with the region that the distance here mentioned is apparently quite too great and that the Black Hills region as now understood does not contain peaks reaching above the snow line as might be inferred from the quotation given. During the early part of the century the term "Black Mountains" or "Hills" was indefinite. According to some the term was apparently used to designate only the mountains between the Laramie plains and the Forks of the Platte. This seems to have been the idea entertained by the early geologists, James and Englemann and others. Many considered the term as referring to the hilly region between the North Fork of the Platte and the Black Hills region as at present defined. This usage is indicated in Figure 2, Plate II, in which is shown a portion of an excellent map published in 1838 by Rev. Samuel Parkér, who made extensive explorations in the Rocky Mountain region during the years 1835-36. More often the term was used to indicate two distinctly separated areas, designated as the Black Hills of Wyoming and the Black Hills of Dakota (or Nebraska). These referred to the Laramie Mountains and to the Black Hills as now understood. Plate IV, which is a reproduction of a portion of the map accompanying Lieut. Warren's "Report of Military Reconnaissances in the Dakota Country, 1855," indicates this usage although the Black Hills of Dakota are on this map made to extend too far to the northwest. The term "Black Hills" was in fact used loosely and

for many years included practically everything mountainous between the Missouri and the Rockies.

We are informed in Irving's Astoria that as early as the summer of 1811 a party under the direction of Wilson P. Hunt, one of the members of the American Fur Company, at the head of which was John Jacob Astor, while en route to the Columbia river from the old Arikaree village at the mouth of the Grand river on the Missouri, skirted the Black Hills on the north. They tried repeatedly to gain entrance into the Hills, but failed on account of the inaccessibility of the canyons where the attempts were made. The exact place of their approach is not known, but the supposition has been entertained by some that it was probably in the vicinity of Spearfish. Owing to this uncertainty the position of their route has been represented conjecturally on the accompanying route map, Plate I. The Hills are described as being "chiefly composed of sandstone and in many places are broken into savage cliffs and precipices, and present the most singular and fantastic forms."*

Notwithstanding this early acquaintance with the Hills, general information concerning the region was for many years extremely meagre. Possibly occasional visits were made into the Hills by parties or individuals, a fur trading post having been established about the year 1830 at or near the junction of the North and South Forks of the Cheyenne river,† but the observations were either not recorded or were of such doubtful accuracy as to be of little scientific value.

Important discoveries along the Missouri had directed the attention of geologists to the central and eastern parts of the state, but not until 1846-7 did they become especially interested in the mountainous western portion. Even then the interest of geologists in the Black Hills region did not originate in discoveries made in the Hills proper, but in the neighboring White River bad lands, the term "bad lands"

*This statement, especially the latter part, seems to refer more particularly to the "bad lands" north-northwest of the Hills.

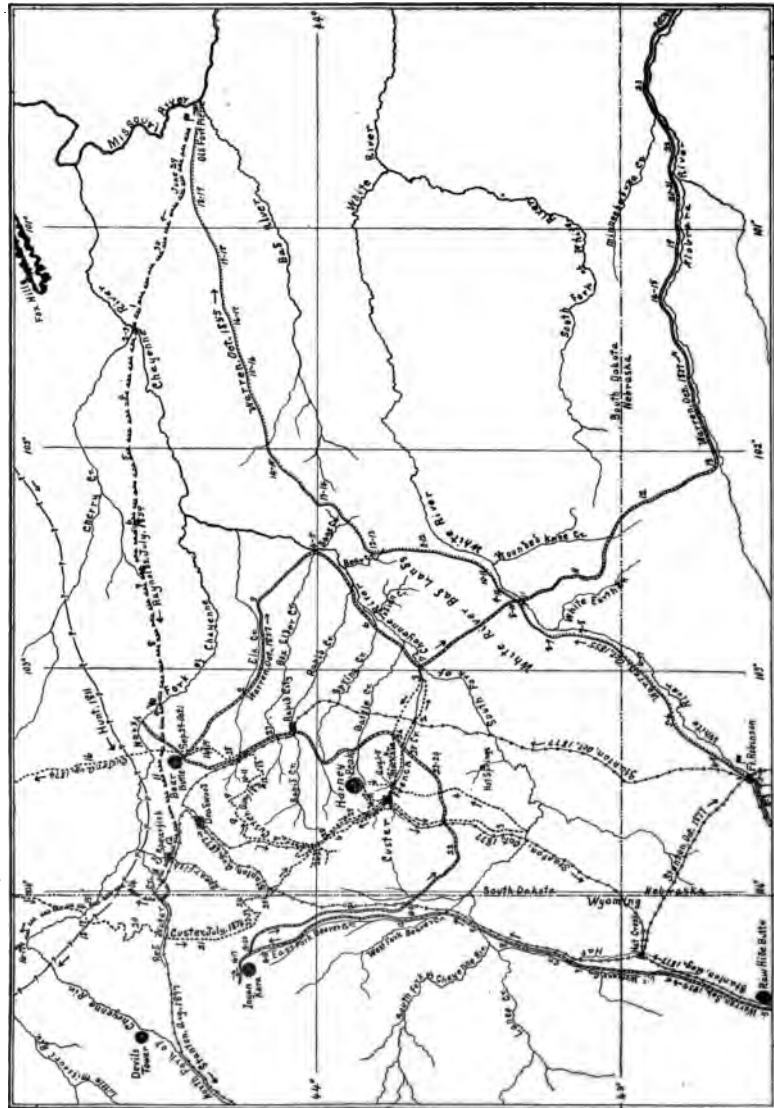
†Maguire, H. N. *The Coming Empire*, Sioux City, Iowa, 1878.

having been given by the early fur traders to this and similar areas on account of their difficulty of passage.*

Traders in the employ of the American Fur Company had at various times brought back interesting specimens of mammalian remains from the White River country and in 1846 Dr. H. A. Prout, of St. Louis, in this way came into possession of a fragment of the fossil lower jaw of one of these animals. The American Journal of Science, vol. II, pp. 288-289, 1846, in Miscellaneous Intelligence, under the head of "Gigantic Paleotherium," gives a description, evidently written by Dr. Prout, of the teeth of this specimen, also a vertical view, natural size, of the posterior tooth, which was well preserved. In the same Journal, vol. III, pp. 248-250, 1847, Dr. Prout, in an article entitled "Description of a Fossil Maxillary Bone of a Palaeotherium near White River," gives a more detailed description of the fossil referred to in the preceding volume. Two figures are given, one of the entire fossil as found and one of the last molar tooth. The locality where discovered is given as "near the latitude of 43 degrees and longitude 26 degrees, or approximately 150 miles south of St. [Ft.] Pierre and 60 miles east of the Black Hills."† About the same time a few specimens obtained in much the same manner as the one described by Dr. Prout were submitted to Dr. Leidy for examination. They form the subjects of short communications in the Proceedings of the Academy of Natural Sciences of Philadelphia for 1847. These articles by Dr. Prout and by Dr. Leidy, which were the first to make public mention of White River fossils, opened the way for the extensive and important researches so persistently carried on in the White River Tertiary since that time.

*Apparently the earliest authentic reference to collections made in the Black Hills proper dates from the year 1850. Professor Ward in his paper on The Cretaceous Formations of the Black Hills as Indicated by the Fossil Plants, U. S. Geological Survey, 19th Ann. Rept., 1899, p. 529, calls attention to Edgar Allan Poe's reference to "the discovery of a completely petrified forest near the head waters of the Cheyenne, or Chienne River, which has its source in the Black Hills of the Rocky chain." The works of the late Edgar Allan Poe, with notices of his life and genius, by N. P. Willis, J. R. Lowell and R. W. Griswold; in two volumes; vol. I, Tales, New York, 1850, p. 139.

†This inaccuracy of location is doubtless due to the general lack of knowledge at that time of the geography of the Northwest.



SKETCH MAP, Showing Routes of Early Exploring Expeditions to the Black Hills Region.



In 1849 Dr. John Evans, under the direction of Dr. David Dale Owen, United States geologist, led the first expedition into the White River bad lands for the purpose of scientific observation. Dr. Evans at this time secured an excellent collection of Tertiary mammalian and chelonian remains and also collected many Cretaceous fossil in neighboring localities, particularly along Sage creek.*

The report of this expedition, which includes our first authentic description of the physical features of these now celebrated "bad lands" is given in Dr. Owen's final report of the Geological Survey of Wisconsin, Iowa and Minnesota, published in 1852. A map, reproduced in Plate III, which is the first detailed mapping of any part of the Black Hills region, also descriptions and many plates of the fossils are given in the report, the vertebrate fossils being described by Dr. Joseph Leidy, the invertebrate fossils by Dr. Owen.

In 1850 Mr. Thaddeus A. Culbertson visited the White River bad lands under the auspices of the Smithsonian Institution and made an interesting collection. This collection, together with material previously obtained, formed the basis of a paper by Dr. Leidy, published in 1852 in the Smithsonian Contributions to Knowledge, under the title of "The Ancient Fauna of Nebraska."

In 1853 Dr. Evans again made extensive collections of Tertiary fossils in the White River beds and also of Cretaceous fossils from the now well-known Sage creek locality. The vertebrates were described by Dr. Leidy in the Proceedings of the Academy of Natural Sciences of Philadelphia. Drs. Evans and Shumard made a study of the invertebrates and published their results in the Proceedings of the Academy of Sciences of St. Louis.

In the same year, 1853, Dr. F. V. Hayden and Mr. F. B. Meek, who with Dr. Leidy, already mentioned, made up

*This Sage creek, which is a southern branch of the South Fork of the Cheyenne river, is east of the Black Hills, wholly within South Dakota, which at the time of Dr. Evans' visit was a part of Nebraska territory. It should not be confused with another tributary of the South Fork of the Cheyenne, known as Upper Sage creek, formerly called Hat creek, lying south-southwest of the Hills in Wyoming.

a trio of scientists to whom especial credit is due for their work in developing the earlier knowledge of the geology and paleontology of the Black Hills region, were employed by Professor James Hall, state geologist of New York, to visit the White River bad lands for the purpose of making a collection of fossils. Their collection of mammalian remains, which was a particularly important one, was submitted to Dr. Leidy for study. The invertebrate Cretaceous forms, which were of no less importance, were studied by Professor Hall and Mr. Meek and furnished a memoir published by the Boston Academy of Science, in which was a section prepared by Mr. Meek, showing for the first time the order of succession of the different beds of the Cretaceous in the Upper Missouri region.

Dr. Hayden, in company with parties of the American Fur Company, spent the years 1854-55 in the Upper Missouri country. On March 9, 1855, he ascended Bear Butte and during the months of May and June of the same year he devoted thirty days to a study of the White River bad lands. The collection secured at this time was equally divided, one part being purchased by the Academy of Sciences of St. Louis and the other part by the Academy of Natural Sciences of Philadelphia.

In 1855 a military force, under command of General W. S. Harney, passed through a considerable part of the Bad Lands along the old trail from Fort Laramie to Fort Pierre. Lieutenant Warren, topographical engineer to the expedition made a report of this exploration, in which is given much of interest concerning the geography, topography, meteorology, etc., of the country passed through. The report is accompanied by a paper written by Dr. Hayden, who gives an account of his work in the Bad Lands a few months previous to the military expedition.

Two years later, in 1857, Lieutenant Warren accompanied by Dr. Hayden as geologist, conducted an expedition almost around the outskirts of the Black Hills. The first reliable geological information concerning the Hills proper was obtained at this time. The party consisting of twenty-two men set out from Fort Laramie September 4th and pro-

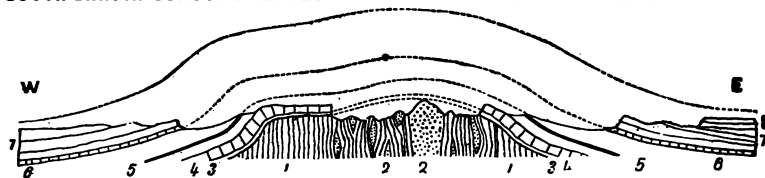


FIGURE 1. Ideal Cross-section of the Black Hills, according to Prof. Newton.

- | | |
|--------------------------------|---------------------------------------|
| 1. Archean slates and schists. | 5. Red Beds, with included limestone. |
| 2. Granite. | 6. Jura. |
| 3. Potsdam. | 7. Cretaceous. |
| 4. Carboniferous. | 8. White River Tertiary. |

Vertical scale approximately six times the horizontal.



FIGURE 2. A portion of Rev. Samuel Parker's map of Oregon Territory, indicating the Black Hills as situated immediately north of the Platte. The hook-shaped ridge within the forks of the Cheyenne, corresponds more closely with the position of the Black Hills as now understood.



•



ceeded direct to the Black Hills by way of Raw Hide Butte, Old Woman creek, South Fork of the Cheyenne and Beaver creek. They entered the outskirts of the Hills along the East Fork of Beaver creek. Continuing northward the vicinity of Inyan Kara was reached, where after several days parleying with a large force of Indians who were herding buffaloes in the Red Water Valley, the party was compelled to return southward. They retraced their route for a considerable distance, then passed around the southern end of the Hills, following in a general way the outer rampart of the Hills eastward, then northward to Bear Butte, which point was reached September 29th. After visiting the North Fork of the Cheyenne the party went from Bear Butte southeast to Elk creek—given in the report as Bear creek—which they followed one day toward its mouth; thence to the South Fork of the Cheyenne, striking it at the mouth of Sage creek. They ascended the Cheyenne to French creek, then crossing the Bad Lands and the White river, passed out of the state between the head waters of Wounded Knee creek and White Earth creek.

Chief among the geological results of this trip was the identification of Cambrian, Carboniferous and Jurassic rocks. From this expedition dates also the careful investigation of the topography and drainage of the region, practically nothing having been known previous to this time concerning the detailed geography of the forks of the Cheyenne. The expedition was in the nature of a rather rapid reconnaissance and although Lieut. Warren had but few instruments his work proved to be unusually accurate and all subsequent maps of the region up to the Newton-Jenney survey of 1875 were based on his work.

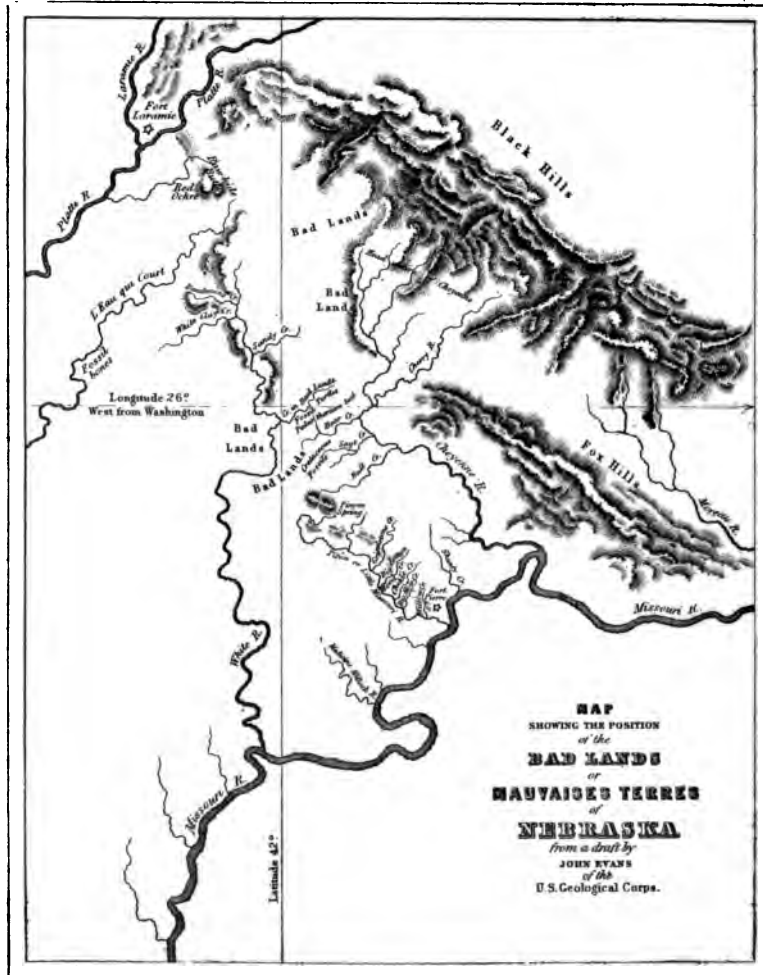
It is especially worthy of mention that the Cambrian of the Black Hills, then known as Potsdam and classified as Lower Silurian according to the usage of the time, was the first discovery of Cambrian rocks in all the Rocky Mountain region; also that Dr. Hayden obtained in the Hills at this time the first positive proof of the existence of Jurassic rocks in America.

In May of this year, 1857, the first geological map of

the northwestern part of the United States which made any pretensions at accuracy, was published by Dr. Hayden in the Proceedings of the Academy of Natural Sciences of Philadelphia. The geology of much of western South Dakota is indicated, but that part of the map representing the Black Hills proper is not colored. In June, 1858, a second edition of this map was published in the Proceedings and in this was incorporated the additional information obtained by the author during the previous year. The geology of the Black Hills proper is represented for the first time on this map.

Plate V is a reproduction of a part of the "Map of Nebraska and Dakota," published in the Journal of the Proceedings of the Academy of Natural Sciences of Philadelphia in 1869, and again in the Final Report of the U. S. Geological Survey of Nebraska, etc., in 1872. It does not therefore represent the earliest map, but it has received a wider circulation than the other and was apparently made from the same notes.

In 1859 Dr. Hayden again visited the Hills, this time as geologist to the expedition led by Capt. W. F. Reynolds. The party left Ft. Pierre June 28th. The Cheyenne was crossed at the mouth of Cherry creek and the North Fork or Belle Fourche near the mouth of Bear Butte creek. Bear Butte was ascended by several members of the party. After leaving Bear Butte the route led along the outer rim of the Hills and the party passed beyond the state in a nearly northwest direction. In his geological report of this exploration, published in 1869, Dr. Hayden summarizes the structure of the Black Hills as follows: "The nucleus or central portion is composed of red feldspathic granite, with a series of metamorphic slates and schists superimposed, and thence upon each side of the axis of elevation the various fossiliferous formations of this region follow in their order to the summits of the Cretaceous, the whole inclining against the granitoid rocks at a greater or less angle. There seems to be no unconformability in the fossiliferous rocks, from the Potsdam inclusive to the top of the Cretaceous. From these facts we



MAP OF THE WHITE RIVER BAD LANDS,
By Dr. John Evans, published in Dr. Owens' Final Report of the Geological
Survey of Wisconsin, Iowa and Minnesota, 1852.—Reduced.



draw the inference that, prior to the elevation of the Black Hills, which must have occurred after the deposition of the Cretaceous rocks, all these formations presented an unbroken continuity over the whole area occupied by these mountains." These structural features, later worked out in greater detail by Professor Newton, are indicated in Figure I, Plate II.

Plate VI is a reproduction of a portion of the geological map based on the notes of this as well as previous expeditions and shows a much better understanding of the region than is indicated in Plate VI.

In 1861, two years after the Reynolds expedition, Messrs. Meek and Hayden published in the Proceedings of the Academy of Natural Sciences of Philadelphia the first complete section of the "Tertiary" Formations of the West. The series was subdivided into the four groups: 1, Fort Union, or Great Lignitic; 2, Wind River; 3, White River; 4, Loup River.

Dr. Hayden visited the Bad Lands for the last time in 1866. He went under the auspices of the Academy of Natural Sciences of Philadelphia, passing up the Niobrara river to the mouth of the Minnechadusa; thence to the head of Little White river, thus observing and collecting in portions of the basin not before visited by him. This expedition closed Dr. Hayden's field work in the Black Hills region, a region whose geological interest was brought to the attention of the scientific world largely through his researches. It is fitting therefore to relate here in Dr. Hayden's own words his idea of the importance of the region as a field for geological study. He says: "The Black Hills of Dakota will form one of the most interesting studies on this continent. There is so much regularity in the upheaval that all obscurity is removed and all the formations known in the West are revealed in zones or belts around the granitic nucleus in their fullest development. A careful detailed topographical and geological survey of this range would be a most valuable contribution to science. In all the western country I have never seen the cretaceous, Jurassic, triassic, or red-beds, the

carboniferous and Potsdam rocks, so well exposed for study as around the Black Hills."*

In 1874 a party of 1000 men under command of Colonel G. A. Custer explored considerable portions of the Hills, including much of the difficultly accessible and hitherto unexplored mountainous area. Captain William Ludlow accompanied the expedition as chief of engineers, Professor N. H. Winchell as geologist and Mr. G. B. Grinnell as naturalist. The party left Fort Abraham Lincoln, near Bismark, North Dakota, July 1st, and traveling in a general southwesterly direction, reached the Belle Fourche a little west of the state line July 18th. From here the route led southward to Inyan Kara; thence southwest to a point on French creek, nearly due south of Harney Peak. Here detachments were sent south to the South Fork of the Cheyenne near the present site of Edgemont; east along French creek nearly to its mouth; and north to the summit of Harney Peak. The main route was then retraced for a distance of about twenty-five miles, after which the party went northeast to the headwaters of Box Elder, which creek they descended to the Red valley. They then went north to Elk creek, where they passed out upon the prairie, then north again to Bear Butte, which some of the party ascended August 15th. The party then crossed the Cheyenne and passed beyond the state line on the return journey. Professor Winchell, as a result of this expedition, published a valuable report, including numerous sections and an important geological map. It is to be noted that he was the first geologist to reach the granite area. Dr. Hayden having had opportunity to study the central portion of the Hills only from a distance. Miners and prospectors accompanying the expedition reported the finding of gold and, although not yet opened by the government for settlement, prospectors began at once to flock to the region.

During this year, 1874, the South Dakota-Nebraska boundary line was surveyed by Mr. Chauncy Wiltse and Mr. E. P. Austin, his assistant, the distance measured betng a little more than 224 miles.†

*Preliminary Report of the United States Geological Survey of Wyoming and Portions of Contiguous Territories, 1870. Washington, 1871, page 98.

†Wheeler, George M., Explorations and Surveys, p. 723, 1889.



A portion of Lieutenant Warren's map accompanying his "Report of Military Reconnaissances in the Dakota Country 1855," showing, approximately, the location of the Black Hills of Dakota and the Black Hills of Wyoming, as then understood.—Reduced.



The following year, 1875, is particularly prominent in the history of the Black Hills. It was during this year that a party was sent out by the Secretary of the Interior under the auspices of the United States Geographical and Geological Survey of the Rocky Mountain Region for the purpose of making a topographical survey and of obtaining information regarding the geology, the mineral deposits and other natural resources of the Hills. The professional work was performed by Walter P. Jenney, E. M., geologist in charge; Henry Newton, E. M., assistant geologist; V. T. McGillicuddy, M. D., topographer; Captain Horace B. Tuttle, A. M., astronomer; and W. F. Patrick, E. M., with a corps of eleven miners and laborers—sixteen in all.

The party, with a military escort of 400 men under command of Lieut.-Colonel R. I. Dodge, left Fort Laramie May 25th and reached the Black Hills on the East Fork of Beaver creek June 3d. From Camp Jenney on the East Fork of the Beaver the entire party entered the Hills proper, establishing the first base of operations at the stockade* on French creek.

"Here in order to expedite the work the corps was divided into two parties: (1) Mr. Jenney with the miners, assumed the work of examining the mineral deposits and prospecting the various districts for gold, and (2) Mr. Newton, Dr. McGillicuddy and Captain Tuttle were directed to undertake the more detailed and thorough topographical and geological study of the country. When the region of the southern part of the Hills had been worked up as completely as was practicable the entire expedition moved northward and established a second camp on Rapid creek below the forks, from which the region on each side was in a similar manner explored; a third camp was made on Bear Butte creek near Terry Peak, and a fourth on Inyan Kara creek, about ten miles southeast of Inyan Kara. From this last point the Bear Lodge range was examined by Mr.

*The stockade was a strong enclosure situated about three miles below the present site of Custer. It was erected in January, 1875 as a protection from hostile Indians by the members of the first expedition to enter the Hills for the purpose of settlement.

Jenney's party, while the other party descended the Belle Fourche to the mouth of Bear Butte creek, where all portions of the expedition again met. The main body of the escort then skirted the Hills on the east side to Rapid creek, while Mr. Jenney's party crossed southeastward outside of the foot hills to the mouth of Rapid creek, and the topographical party descended the Belle Fourche and ascended the South Fork of the Cheyenne to the mouth of Rapid creek, where all parts of the expedition met September 22, preparatory to the homeward march. * * * * From the mouth of the Rapid the surveying party ascended the Cheyenne river to the mouth of Burntwood creek, and then, crossing eastward to the White river, joined the main body of the military escort, which had crossed through the Bad Lands from near Spring creek. Thence following up the White river, via, the Indian agencies of Spotted Tail and Red Cloud, the expedition returned by the agency road to Fort Laramie."*

The work of the party, although limited to a single season, was carefully done and the accumulation of facts was particularly satisfactory. Prof. Jenney's preliminary report on the mineral and other resources, in which much of immediate interest centered, was published in 1876. It cleared away all lingering doubts as to the presence of gold in the Black Hills,† a considerable part of the report dealing especially with this subject. It also contains a description of various mining-districts in the Hills and a discussion of the climate, water supply, soil, wild fruits, grazing and timber. The final report of the expedition, delayed at first because of the lack of appropriation and again on account of the death of Prof. Newton, which occurred at Deadwood, August 5, 1877, was published in 1880, Mr. G. K. Gilbert ably editing Prof. Newton's unfinished manuscript. Prof. Newton showed

*Report on the Geology and Resources of the Black Hills of Dakota, with atlas, by Henry Newton, E. M., and Walter P. Jenney, E. M., 1880, pp. 34-37.

†Prof. Jenney's first announcement of the finding of gold dates really from June 17, 1875, at which time he sent a message from "Camp on French creek, near Hørney Peak," to the commissioner of Indian affairs at Washington, announcing that he had found gold on the north bend of Castle creek, and southward to French creek.



Portion of Dr. Hayden's "Map of Nebraska and Dakota," 1869 and 1872. Figures and dotted contact lines not in original.—Reduced.

[REDACTED]

a clear grasp of the geological problems incident to the region and discussed them in a comprehensive manner. His report is a geological classic on the Black Hills region and is a fitting monument to his memory.

In addition to the papers by Prof. Newton and Prof. Jenney four other papers were presented in the final report. Mr. Tuttle reported on the astronomical and barometric work; Professor Asa Gray on the collection of plants; Mr. John H. Caswell on the microscopic petrography and Professor R. P. Whitfield on the paleontology. The collection of fossils is said to have contributed a larger amount of new material than that gathered by any previous single expedition to the west. Among the important results of Mr. Caswell's work was the accurate determination of various rock species among the later igneous intrusions of the Northern Hills. It is of interest to note that he announced the discovery of phonolite at Black Butte, this being the first discovery of phonolite in America.

An atlas of three maps accompanies the report. Of these the topographical map and the geological map served as the basis for all later field work until the beginning of the more detailed survey now being carried on under the direction of the United States Geological Survey. The geological map of that portion of the area lying in South Dakota is reproduced with slight revision, in Plate VII. The third map, a birds-eye view of the Hills, reproduced in Plate VIII, shows the general relief of the region and indicates in a beautiful manner the topographical relation which the Hills bear to the surrounding plain. In addition to the reports by the members of the scientific staff, Lieut.-Colonel Dodge published in 1876 an interesting and helpful book descriptive of the region.

In 1877 Capt. W. S. Stanton, with a party of forty-one men, made important explorations into the Hills. Capt. Stanton, who had charge of the party and superintended the observations for time, latitude and magnetic declination was unaccompanied by a geologist, but had as members of the party a topographer and draftsman and a photographer, besides chain and rod men and a military escort.

The party, leaving Fort Laramie August 1st, and enter-

ing the Hills by way of Raw Hide Butte, Hat creek, [now called Upper Sage creek?] Old Woman creek, Beaver creek and Camp Jenney, reached Deadwood, August 11th. They remained at Deadwood six days, making observations for latitude and longitude, after which the journey was continued northwest to Spearfish, thence west and southwest up the valleys of the Red Water and the Belle Fourche to Fort McKinney. This route from Deadwood was at that time the usual line of travel from the Black Hills to the Big Horn mountains, but so far as concerns that portion of the Belle Fourche along which the reconnaissance led little accurate information was known at that time.

Later in the season the party again entered the Hills from Fort Laramie. They left Fort Laramie, September 28th, for Fort Robinson, from which place they went nearly due north along the old Sidney-Deadwood stage and mail route to Rapid City, where they entered the Red valley, thence to Deadwood, October 11th, by way of Crook City. The route then led southward through Custer, where a stop was made for special observations; thence south-southwest to Hat creek; thence southeast to Fort Robinson, which place was reached October 25th. During these explorations observations were made as to latitude, longitude, altitudes, distances, comparative advantages of routes, grazing and agricultural lands. The earlier route taken by the party into the Hills was the old mail and stage route from Cheyenne to Deadwood. This had two branches from Hat creek. The eastern branch was the early stage route, but later the western branch was used instead. Captain Stanton's party first entered the Hills by way of the western branch, but later one of their routes led outward along the eastern branch.

During this year, 1877, the southern part of the Dakota-Wyoming boundary line was surveyed by Mr. Rollin B. Reeves and Mr. Horace P. Tuttle, his assistant, the distance measured being a little more than 138 miles.

Following the Newton-Jenney survey little additional information was gained so far as concerns the general geology of the Hills until the year 1888, when two publica-



A portion of Dr. Hayden's "Map of the Yellowstone and Missouri Rivers and their Tributaries," published in 1869. Figures and dotted contact lines not in the original.—Reduced.



tions of importance were issued. The first of these was by Professor W. O. Crosby, on the "Geology of the Black Hills of Dakota," and was published in the Proceedings of the Boston Society of Natural History. Among the principle features discussed in this paper the following may be mentioned: the geological history of the region, the origin of the granite, the presence and metamorphism of the pre-cambrian conglomerate, the nature of the igneous intrusions of the Northern Hills, some of which were shown to be true laccolites, the formation of the contact ore deposits and the cause of the deposit of gravel and boulders, which cover the prairie for many miles beyond the limits of the Hills.

The second paper, published in 1888, was a preliminary report on the geology and mineral resources of the Hills, by Dr. Franklin R. Carpenter, then dean of the State School of Mines. The conclusions reached by the author concerning the general geology of the region are much the same as those given by previous writers. The discovery of prominent pre-Cambrian conglomerates and of pre-Cambrian igneous rocks provisionally classed as diorites, is announced in the paper. Under the head of Mineral Resources the author gives a general review of the mineral industry as existing in the Hills at the time and discusses at considerable length the occurrence of gold and tin. A copy of Newton's geological map modified to show the results of later study is also given in the report. Plate VIII is a reproduction of this map as given by Mr. Persifor Frazer in his "Notes on the Northern Black Hills of South Dakota," published in the Transactions of the American Institute of Mining Engineers in 1897.

During the same year, 1888, Professor Crosby published in the Technology Quarterly a short paper on "Quartzites and Siliceous Concretions," the paper having been suggested by observations of certain phenomena on Box Elder creek. The part of the discussion referring particularly to the Hills deals mostly with the silicification of the Cambrian quartzite.

During the summer of the following year, 1889, Professor C. R. Van Hise visited the region for the purpose of studying the older rocks and in March of the following year, 1890, published in the Bulletin of the Geological Society of Amer-

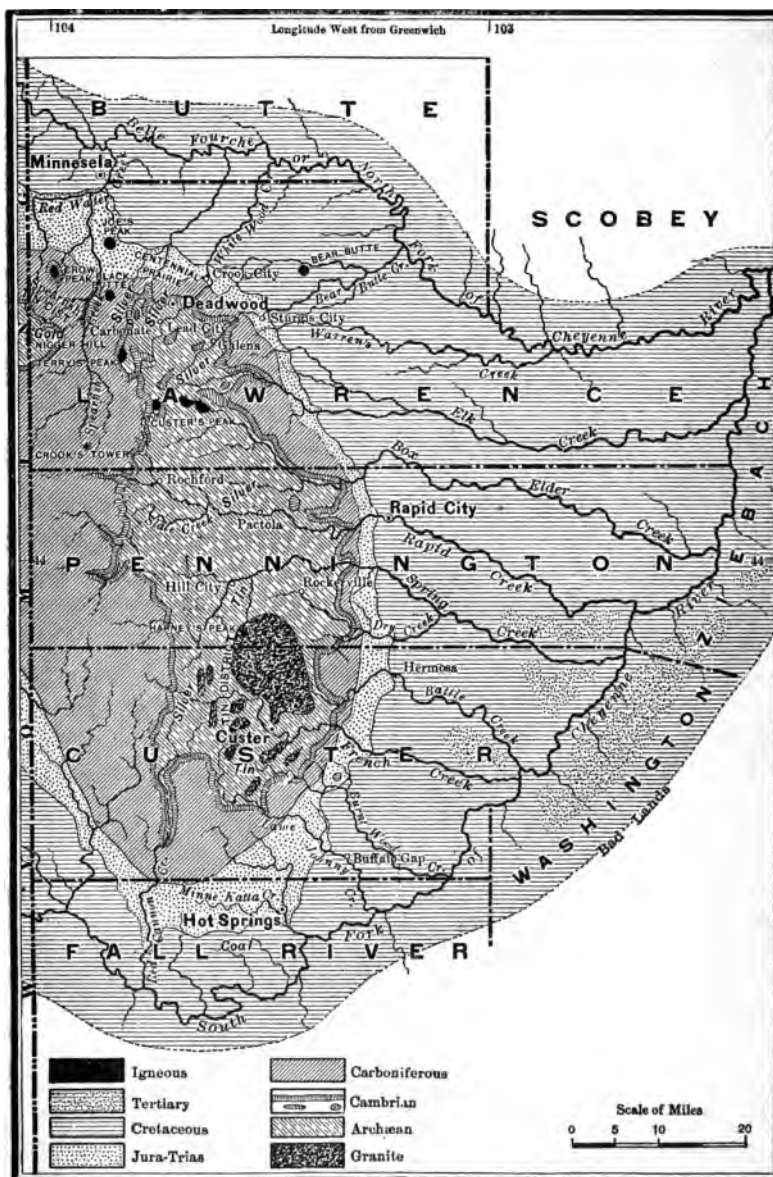
ica a paper, on "The Pre-Cambrian Rocks of the Black Hills." The more important results of his work were: the rearrangement of the areal distribution of the schists and slates as mapped by Newton; the presentation of evidence that the basic eruptives, such as hornblende schists and diorite are probably older than the eruptive granite; that the pre-Cambrian quartzites, quartz schists, mica slates, and certain of the mica gneisses are of clastic origin, while the hornblende schists are, at least in some instances, of eruptive origin; and that slaty cleavage, schistose structure and true bedding, although closely related to each other, are distinct phenomena and are all well represented in the pre-Cambrian rocks of the Hills.

The year 1892 marks the discovery of Silurian strata in the Hills. During this year Mr. C. D. Wolcott, director of the United States Geological Survey, published a paper in the Bulletin of the Geological Society of America entitled "Preliminary Notes on the Discovery of a Vertebrate Fauna in Silurian (Ordovician) Strata," in which he refers in a foot note to the receipt from Dr. F. R. Carpenter of specimens of invertebrate fossils, which establish the identity of Trenton strata.

In 1893 two valuable contributions to the geological literature of the White River bad lands were published. The first of these by Mr. J. B. Hatcher, entitled "The Titanotherium Beds," was published in the American Naturalist and deals especially with the lithological character, areal distribution, method of deposition and triple division of the beds.

The second paper was by Dr. J. L. Wortman "On the Divisions of the White River or Lower Miocene of Dakota," and appeared in the Bulletin of the American Museum of Natural History. The paper announced the discovery of a well-defined fossiliferous horizon above the already well-known Oreodon beds. The strata containing the fossils were designated by the author as the "Protoceras layer," from the characteristic vertebrate fossil, known as Protoceras, found in them in considerable abundance.

The next publication containing a study of the general



Geological map of the Black Hills of Dakota, after the map of Professor Newton. Revised by Dr. F. R. Carpenter. Reproduced from Professor Frazer's "Notes on the Northern Black Hills of South Dakota."



geology of the Black Hills region was issued in 1894 as Bulletin No. 1 of the South Dakota Geological Survey, by Professor J. E. Todd, state geologist, under the title, "A Preliminary Report on the Geology of South Dakota." The report contains an excellent summary description of the geology of the Black Hills region as known up to that time and testifies to the accurate discriminating judgment of the author in discussing the results of previous work. Many new facts are also presented, the author having spent several weeks in the Hills making personal observations.

In 1898 Bulletin No. 2 of the South Dakota Geological Survey was published. Six of the scientific papers contained in this bulletin deal more or less directly with portions of the Black Hills region. The work was carried on under the direction of the state geologist, mostly during the summer of 1895, and resulted in the discovery of important facts regarding the structure and stratigraphy of the region. Among the facts brought out in these papers may be mentioned: the discovery of fossils in the lower part of the Purple Limestone; complex folding in the slates along Rapid creek; White River and Loup Fork Miocene beds overlying the Laramie north of the Black Hills in Harding, Butte and Ewing counties; an area of considerable disturbance in Harding county; and lignite beds of importance in Ewing, Harding and Martin counties.

In 1899 Mr. John D. Irving, of the Geological Department of Columbia University published an important paper entitled, "A Contribution to the Geology of the Northern Black Hills." This gives a detailed account of the geology of an area about eight miles square lying to the south of Little Crow peak and west of Central City and Englewood. The author describes the topography, the sedimentary and igneous rocks and the ore bodies of the region, announces the determination of several new types of igneous rocks, describes the structural and dynamic relations of the eruptives, indicates the causes influencing the formation of the various kinds of Black Hills intrusives and gives a geological map showing the areal distribution of the rocks studied. The ore bodies are described with reference to their method

of formation and their present relations in the several mining localities of the area.

In addition to the papers already mentioned, all of which deal more or less fully with the general geology of the Black Hills region numerous other publications have aided greatly in bringing about an accurate understanding of the geology. Owing to the fact that most of these papers are, in the main, restricted to some phase of economic geology or to particular subjects of a mineralogical, petrographical or paleontological character no effort is made here to review them in detail. In the bibliography published as the second paper of this bulletin, the general nature of the contents of each paper has been indicated. The first three classes of the publications above mentioned are closely related and aside from indicating many interesting geological features of the region have directed careful attention to its valuable mineral resources. Concerning these mineral resources it need only be said that the knowledge of their varied nature has become widespread and the financial interests permeating every part of the region and assisting in its development is unmistakable evidence of their economic importance.

In recounting the work carried on in the White River bad lands the various earlier expeditions to the region have been mentioned in consecutive order with some reference to the special results of each expedition. Since Dr. Hayden's last visit few field seasons have gone by without one or more collecting parties entering the basin for the purpose of obtaining specimens from its well-filled beds. The detailed results of all of this work, which in the main is of a highly special nature, cannot be dwelt upon here. It must suffice to mention some of the institutions represented and the years in which the visits were made. Professor Marsh visited the region for the first time in 1868. Since then Yale University, through the instrumentality of Professor Marsh, has had collecting parties in the field during portions of thirteen different seasons, as follows: 1870, 1871, 1873, 1874, 1886, 1887, 1888, 1889, 1890, 1894, 1895, 1897, 1898.* The earlier parties were made up of instructors and students

*A portion of the time indicated was spent in northwestern Nebraska.



Bird's-eye view of the Black Hills, reproduced from the atlas accompanying the report of the Newton-Jenney survey. — Reduced



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from the university. Later the parties included only local collectors. Princeton University also early took an interest in the region, the first party, under the direction of Professor W. B. Scott, entering the Bad Lands in 1882. Collecting parties were again sent out in 1890, 1893 and 1894, the party of 1890 being as before under the personal direction of Professor Scott, that of 1894 under the direction of Mr. Hatcher, while the collections of 1893 were directed by both Professor Scott and Mr. Hatcher. The American Museum of Natural History was represented by parties under the direction of Dr. J. L. Wortman during the season of 1892 and 1894 and the Field Columbian Museum in 1898 by a party under the direction of Professor O. C. Farrington. Other universities and museums have occasionally had representatives in the field and local collectors have supplied specimens to many institutions, both in America and in Europe. The result is that to the White River bad lands some of our best equipped museums owe many of their finest specimens of fossil mammalian remains and our scientists one of the most fruitful sources of paleontologic interest.

Reference has already been made to the surveys and explorations carried on in the Black Hills region under the direction of various government organizations before the establishment in 1879 of the present United States Geological Survey. Mention of the work of this latter organization has been purposely omitted in the foregoing pages although the consecutive order of investigation, as followed in the major portion of this paper, might seem to demand its earlier presentation. I have reserved mention of this work until the last, partly because of its present continuation, partly because of its more or less connected nature, but particularly because of the fact that the very character of that work is calculated to arouse new interest in the geology of the Hills and bids fair to mark a new period in the investigation of the region.

The U. S. Geological Survey began work in the Black Hills region in the year 1890, at which time the initial astronomical point on which the triangulation of the region depends was established in the court house yard in Rapid City, by Mr. S. S. Gannett, assisted by Mr. A. F. Dunnington, the

object being to prepare a topographic map of the region suitable for use in subsequent detailed geologic mapping. During the field season of 1891 Mr. C. H. Fitch selected a base line in the valley of the Box Elder creek about four miles northeast of Rapid City, of which he made a preliminary measurement. Topographic work was carried on in the vicinity of Rapid City and Deadwood, by Messrs. R. A. Farmer and C. H. Fitch, the Rapid quadrangle being surveyed as well as portions of the Deadwood and Hermosa quadrangles. During the year 1893 Mr. E. M. Douglas extended the system of triangulation, previously begun by Mr. W. S. Post, over much of the region, locating eighteen stations and carefully remeasuring the base line previously established by Mr. Fitch. In the same season the Harney Peak and the Oelrichs quadrangles were surveyed, Mr. R. A. Farmer surveying most of the Harney Peak quadrangle, and Mr. F. M. Bannon surveying the Oelrichs quadrangle, and the unfinished portion of the Harney Peak quadrangle.*

In 1896 the U. S. government incorporated a considerable portion of the wooded area of the Black Hills region in the Black Hills Forest Reserve, since which time the Geological Survey has again engaged in the work of mapping the region, making some revisions in earlier work and carrying the survey into new areas. As a result of this and previous work six topographic sheets have been issued as follows:†

Name of Sheet.	Scale.	Contour interval	Triangulation by	Topography by
Rapid.....	Two miles to the inch.	50 feet	W. S. Post.	R. A. Farmer.
Hermosa.....	" " " "	100 "	E. M. Douglas	R. A. Farmer.
Deadwood.....	" " " "	100 "	E. M. Douglas	C. H. Fitch and R. A. Farmer.
Oelrichs.....	" " " "	50 "	E. M. Douglas	T. M. Bannon.
Harney Peak.....	" " " "	100 "	E. M. Douglas	R. A. Farmer and T. M. Bannon.
Sundance.....	" " " "	50 "	W. S. Post.	H. S. Wallace.

*A quadrangle, as defined by the United States Geological Survey is bounded by parallels and meridians and on the scale used in the Black Hills contains one-quarter of a square degree, or approximately 1000 square miles. The published topographic map of the quadrangle is known as a topographic sheet.

†These sheets may be procured by anyone for five cents each by addressing The Director, U. S. Geological Survey, Washington, D. C.

Thus the United States Geological Survey, having largely removed one of the most serious obstacles in the way of producing an adequate geological survey of the region, in 1898 entered upon a thorough investigation of its geology. Since that time all of the quadrangles have been wholly or partially studied, the results of which will, without doubt, prove an important factor in the future development of the Black Hills region.

In connection with this work three papers of particular interest have already appeared. One by Mr. Henry S. Graves on the "Black Hills Forest Reserve,"* another by Professor Lester F. Ward on "The Cretaceous Formations of the Black Hills as Indicated by the Fossil Plants,"† and a third by Mr. N. H. Darton on the "Jurassic Formations of the Black Hills of South Dakota."‡

Mr. Graves defines the limits of the reserve and describes the topography of the region. He indicates the lands suitable for agricultural, grazing and mining purposes, as well as the character, distribution, condition and yield of the forest covered areas, suggests methods of management and gives a detailed description of the forest as developed along the various streams of the Hills.

Professor Ward gives a history of our knowledge of the Cretaceous of the Hills, indicates the lower Cretaceous age of a considerable series of strata below the Dakota sandstone, describes the Cretaceous flora, particular attention being given to the Cycads which occur extensively developed in the region and gives in detail the geology of the Minnekahta, the Black Hawk and the Hay Creek regions. Professor Jenney contributes the field observations in the Hay Creek coal field, Professor Fontaine the notes on the lower Cretaceous plants from the same field and Dr. Knowlton on the

*U. S. Geol. Survey, 19th Ann. Rept., part V, pp. 67-167, pls. XIX-XXXVI.

†U. S. Geol. Survey, 19th Ann. Rept., part II, pp. 527-946, pls. LIII-CLXXII, figs 117-122.

‡Geol. Soc. Amer., Bull., vol. 10, pp. 383-396, pls. 42-44.

fossil wood, genus *Araucarioxylon*, from the cycad bed two miles southwest of Minnekahta station.

Mr. Darton gives a general discussion of the Black Hills Jurassic as now understood, points out the uncertainty of the Jurassic-Cretaceous contact horizon, gives the classification, composition, and nomenclature of the Triassic, Jurassic and Lower Cretaceous (or Jurassic?) formations, describes the formations in detail as developed in various localities and outlines the history of Jurassic deposition in the Black Hills region.

A BIBLIOGRAPHY

Of Contributions to the Geology and Geography of the Black Hills Region.*

BY CLEOPHAS C. O'HARRA.

1846.

1. [PROUT, HIRAM A.] Gigantic Palaeotherium.

Am. Jour. Sci., vol. II, pp. 288-289.

This is published under the head of Miscellaneous Intelligence and is the first reference to organic remains from the White River bad lands of South Dakota. The specimen, which is a portion of the lower jaw, was obtained by Dr. Prout, of St. Louis, from individuals in the employ of the American Fur Company. A few measurements of the posterior tooth are given.

1847.

2. PROUT, HIRAM A. A Description of a Fossil Maxillary Bone of a Palaeotherium from near White River.

Am. Jour. Sci., vol. III, pp. 248-250. Communication dated St. Louis, December 10, 1846.

The fossil is described as having been discovered near latitude 43° north and longitude 26° west, or approximately 150 miles south of St. [Ft.] Pierre, and 60 miles east of the Black Hills. The specimen is a fragment of the inferior maxillary of the left side, consisting of the posterior part of the bone, together with the last three molar teeth, the last one of which

*This bibliography is not complete. Lack of opportunity has prevented the thorough examination of all of the geological literature; therefore a number of papers are necessarily omitted. This will perhaps be most noticeable to those interested in vertebrate paleontology. Frequent requests for a list of publications on the geology of the region have led to the publication of the bibliography as here presented. With the exception of Nos. 123, 132, 133, 145, 146, only the titles of papers are given which I have personally examined. In the case of the exceptions the titles, summaries of contents, etc., have been taken from the U. S. Geological Survey bibliographies by Mr. Fred B. Weeks, the number of the bulletin being indicated.

is quite well preserved. One figure of the entire fossil one-fourth natural size, and one figure of the last molar tooth four-fifths natural size, are given.

1852.

3. LEIDY, JOSEPH. Description of the Remains of Extinct Mammalia and Chelonia from Nebraska Territory, Collected During the Geological Survey under the Direction of Dr. David Dale Owen.

Report of a Geological Survey of Wisconsin, Iowa and Minnesota, and Incidentally a portion of Nebraska Territory, by David Dale Owen, United States Geologist, Philadelphia, 1852, pp. 533-572, tables IX-XV, map.

The author considers the strata as being of Eocene age and describes the following forms: *Oreodon Culbertsoni*, *O. gracilis*, *Palaeotherium? proutii*, *Rhinoceros occidentalis*, *R. nebrascensis*, *Archaeotherium mortoni*, *Eucrotaphus auritus*, *Machairodus primaevus*, *Testudo nebrascensis*, *T. oweni*, *T. culbertsonii*, *T. hemispherica*. A synopsis of the following forms obtained from the same region is also given: *Poebrotherium wilsoni*, *Agriochoerus antiquus*, *Archaeotherium robustum*, *Architherium bairdii*, *Testudo lata*.

4. OWEN, DAVID DALE. Incidental Observations on the Missouri River, and on the Mauvaises Terres (Bad Lands).

Report of a Geological Survey of Wisconsin, Iowa and Minnesota, and Incidentally a portion of Nebraska Territory, by David Dale Owen, United States Geologist, Philadelphia, 1852. pp. 194-206, one fig., one map.

This paper contains the report of Dr. John Evans, who visited the White River bad lands during the summer of 1849. Mentions the finding of numerous and well-preserved fossils on Sage creek. Describes briefly the peculiar topographic features of the bad lands and the general nature of the fossils found. Considers the beds as of Eocene Tertiary age, and as having been deposited in fresh water. A view of the bad lands and a columnar section are given. The map by Dr. Evans is the first detailed map of any part of the Black Hills region.

5. ——— Description of New and Imperfectly Known Genera and Species of Organic Remains, Collected During the Geological Survey of Wisconsin, Iowa and Minnesota.

Report of a Geological Survey of Wisconsin, Iowa and Minnesota, and Incidentally a Portion of Nebraska Territory, by David Dale Owen, United States Geologist, Philadelphia, 1852. pp. 573-587, tables I-VIII.

Describes and figures the following named fossils from Sage creek,

near the Bad Lands: *Baculites compressus*? B. (undet.) *Scaphites nodosus*, *Inoceramus nebrascensis*.

1854.

6. LEIDY, JOSEPH. The Ancient Fauna of Nebraska, or a Description of Remains of Extinct Mammalia and Chelonia from the Mauvaises Terres of Nebraska.

Smith. Contrib. Knowl., vol. VI., pp. 1854.

Paper based on collections submitted by the Smithsonian Institution. Dr. David Dale Owen, Dr. Hiram A. Prout and Professor O'Loghland. The fossils described were all found in the White River bad lands, South Dakota being at that time included within the Territory of Nebraska. Gives a resume of our knowledge of Tertiary mammals of North America, includes a bibliography of the literature and reviews the earlier explorations in the Bad Lands. Describes fifteen species of Mammalia, five species of Chelonia, gives twenty-four excellent plates of several figures each and a map of the Bad Lands by Dr. John Evans.

1856.

7. HAYDEN, FERDINAND V. [Sketch of the Geology and Physical Features of the Region of the Upper Missouri.]

Explorations in the Dakota country in the year 1855, by Lieutenant G. K. Warren, Topographical Engineer of the "Sioux Expedition," 85th Cong., 1st Sess., Sen. Ex. Doc. No. 76, pp. 66-76, Washington.

Includes an account of the author's visit to the White River bad lands in May and June, 1855, at which time a good collection of fossils was obtained. Mentions the fact of his ascending Bear butte on March 9th, preceeding the visit to the Bad Lands.

8. WARREN, LIEUTENANT G. K. Report of the "Sioux Expedition" of Explorations in the Dakota country, 1855.

84th Cong., 1st Sess., Sen. Ex. Doc., No. 76, pp. 1-62, 2 figs., maps, Washington, 1856.

Gives a general account of the exploration, including brief descriptions of the Black Hills and the Bad Lands and the various rivers draining the region. Appendix A, accompanying the report, gives a detailed journal of the routes, and Appendix D, daily observations of weather conditions. Three maps accompany the report.

1861.

9. HAYDEN, FERDINAND V. On the Geology and Natural History of the Upper Missouri.

Am. Phil. Soc., Trans., vol. XII., pt. I, pp. 1-230, map.

Contains the substance of a later official report made by Dr. Hayden, surgeon and geologist of the Expedition to the Upper Missouri

and Yellowstone, under the command of Lieutenant Warren. Gives an account of the work of previous explorers. Much of the paper is taken up with the geology in the immediate vicinity of the Black Hills, this being the first detailed account of the geology of the region. Numerous columnar sections are given, and certain correlations are made. An outline reduction of the map of Kansas, Nebraska and Dakota, showing topography by Warren and geology by Hayden, is also given.

This paper, with little change, was published by the United States government in 1869, under the title, "Geological Report of the Exploration of the Yellowstone and Missouri Rivers."

10. MEEK, F. B., and HAYDEN, F. V. Descriptions of New Lower Silurian (Primordial), Jurassic, Cretaceous and Tertiary Fossils Collected in Nebraska by the Exploring Expedition under the command of Captain W. F. Reynolds, U. S. Topographical Engineer; with some Remarks on the Rocks from which they were obtained.

Phil. Acad. Nat. Sci., Proc., pp. 415-447.

Refers frequently to fossils from Black Hills localities.

1864.

11. MEEK, F. B. and HAYDEN, F. V. Paleontology of the Upper Missouri.

Am. Phil. Soc., Trans., May; pp. 1-135, pls. I-XX, many figures.

This is the first part of a work containing descriptions and illustrations of the invertebrate fossil remains collected by Dr. Hayden and others while connected with the exploring expeditions under the command of Lieutenant G. K. Warren. Preliminary notices of most of the species described had been previously published from time to time under the joint names of the authors, in the Proceedings of the Philadelphia Academy of Science. These were later largely rewritten and extended by the senior author, Mr. Meek. Frequent reference is made to fossils collected in the Black Hills region.

1868.

12. RAYNOLDS, CAPT. W. F. Report on the Explorations of the Yellowstone River.

Rept. Sec. War, 40th Cong., 1st Sess., Ex. Doc., No. 77, 174 pp., map.

Gives a journal account of the explorations and makes various references to the Black Hills region, the observations having been made while skirting the Hills on the north.

1869.

13. HAYDEN, F. V. Geological Report of the Exploration

of the Yellowstone and Missouri Rivers, under the Direction of Captain W. F. Reynolds in 1859-60.

8vo, 174 pp., map, Washington.

This paper, with little change was published in the Transactions of the American Philosophical Society, vol. XII, pt. I, pp. 1-280. See 1861.

14. ——— On the Geology of the Tertiary Formations of Dakota and Nebraska.

Phil. Acad. Nat. Sci., Journ., vol. VII, pp. 9-21., map.

Reviews the Tertiary history of the West. Describes the areas covered by Tertiary lakes, gives a general section of the Tertiary rocks of Nebraska—including South Dakota, a vertical section showing the order of superposition of the different beds of the Tertiary basin of White and Niobrara rivers. Discusses the origin of the sediments and method of accumulation of the fossils and gives a catalogue of the animals thus far discovered in the White River basin, showing the vertical range of the species. The geological map accompanying this paper shows an error in the coloring by a transfer of the colors used for the granite and metamorphic to the Potsdam sandstone and *vice versa*.

15. LEIDY, JOSEPH. The Extinct Mammalian Fauna of Dakota and Nebraska, Including an Account of Some Allied Forms from other Localities, together with a Synopsis of the Mammalian remains of North America.

Phil. Acad. Nat. Sci., Jour., vol. VII, pp. 23-472, pls. I-XXIX.

Gives a brief account of the early expeditions to the White River bad lands. Describes the manner and the degree of petrification of the bones. Describes and figures seventy-seven species of mammals, most of which are from the White River beds and believed to be of Miocene age.

1871.

16. HAYDEN, FERDINAND V. Geology of the Missouri Valley.

Prelim. Rept. U. S. Surv. of Wyoming and Portions of Contiguous Territories, 1871, pp. 85-188., map.

Gives a general section of the Cretaceous rocks of the Northwest, also a general section of the Tertiary rocks of Nebraska, including what is now South Dakota. Indicates the value of a careful topographical and geological survey of the Black Hills region and gives an interesting description of the White River bad lands with a figure of the same. In

the geological map accompanying his paper the error in coloring referred to in No. 14, is also observed.

17. LEIDY, JOSEPH. Report on the Vertebrate Fossils of the Tertiary Formations of the West.

Prelim. Rept. U. S. Geol. Surv. of Wyoming and Portions of Contiguous Territories, 1871, pp. 340-370.

Brief notice of vertebrate fossils collected in the Tertiary deposits of the West, many of which were obtained in the White River bad lands. A fuller account of most of these is given by the author in "The Extinct Mammalian Fauna of Dakota and Nebraska," published in 1869.

18. ——— Remarks on Fossil Vertebrates from Wyoming.

Phil. Acad. Nat. Sci., Proc., Aug. 8, 1871.,

Contrasts the Wyoming Tertiary fauna with the later fauna of the bad lands of the White River and of the Niobrara of Nebraska. States that "among the large number of fossils from these two localities, rich in evidence of mammalian life, there occur the remains of a single species of turtle in each and none of crocodiles or other reptiles."

19. NEWBERRY, JOHN S. The Ancient Lakes of Western America; Their Deposits and Drainage.

Am. Nat., vol. IV, pp. 641-660.

An interesting discussion of the lakes, particularly those of Tertiary age, but makes no specific mention of the White River bad lands. Published also in the Preliminary Report, U. S. Geological Survey of Wyoming and portions of Contiguous Territories, 1871, pp. 329-339.

1873.

20. LEIDY, JOSEPH. Contributions to the Extinct Vertebrate Fauna of the Western Territories.

U. S. Geol. Surv. of the Terr., Rept., vol. I, pt. I, 358 pp.; pl. I-XXXVII.

Refers frequently to the fossils from the White River Tertiary by way of comparison.

1875.

21. GRINNELL, GEORGE B. Paleontological Report.

Eng. Dept., U. S. Army, Report of a Reconnaissance of the Black Hills of Dakota, made in the summer of 1874, 8vo, pp. 75-78.

Gives names of fossils and localities where collected.

22. HAYDEN, FERDINAND V. Catalogue of the Collections in Geology and Natural History Obtained under Command of Lieutenant G. K. Warren.

U. S. Army, Eng. Dept., Rept. to Lieut. G. K. Warren in his Report to Captain A. A. Humphreys, pp. 61-125.

Discusses the results of geological study in Nebraska and Dakota,

by Dr. Hayden, chiefly while with Lieutenant Warren. Gives various columnar sections and tables of collections. Much of the paper refers to the Black Hills region.

23. LUDLOW, WILLIAM. Engineers' Report.

Eng. Dept., U. S. Army, Report of a Reconnaissance of the Black Hills of Dakota, made in the summer of 1874, 8vo. pp. 1-19., map.

Gives an account of the organization of the party and a general description of the country passed through. Tables of observations for time and latitude accompany the report.

24. MARSH, OTHNIEL C. Notice of New Tertiary Mammals.

Am Jour. Sci., 3d ser., vol. IX, pp. 239-250.

Describes *Laopithecus robustus* from the Oreodon beds of the White River Miocene.

25. ——— Ancient Lake Basins of the Rocky Mountain Region.

Am. Jour. Sci., 3d ser., vol. IX, pp. 49-52.

Describes the Eocene, Miocene and Pliocene lake basins including the White River basin near the Black Hills.

26. WARREN, LIEUT. G. K. Preliminary Report of Explorations in Nebraska and Dakota in the years 1855-56-57.

U. S. Army, Eng. Dept., Rept. to Capt. A. A. Humphreys, 8vo., 125 pp., map.

Gives an account of routes explored, the geography, character of soil and resources, climate, comparative advantages of different routes, etc. Much of this has to do with the immediate vicinity of the Black Hills.

27. WHITFIELD, ROBERT P. Descriptions of New Fossils.

Eng. Dept., U. S. Army, Report of a Reconnaissance of the Black Hills of Dakota, made in the summer of 1874, 8vo pp 103-104, pl.

Describes and figures *Obolus pectenoides* and *Terebratula helena*, also figures *Lingulepis primaeformis*.

28. Winchell, N. H. Geological Report.

Eng. Dept., U. S. Army, Report of a Reconnaissance of the Black Hills of Dakota, Made in the Summer of 1874. 8vo. pp. 21-66, map.

Gives results of the geological investigations in journalistic form without especial effort at generalization. Many sections and figures are given. Distinguishes and defines the Minnelusa sandstone, the name being derived from the Minnelusa valley, in the western part of

Hills. Determines the geological age of some of the rocks more definitely than had been possible in previous surveys. A valuable geological map accompanies the report.

1876.

29. DODGE, LIEUT. COL. RICHARD I. The Black Hills.

Sm. 8vo., 151 pp., 14 pls. New York, 1876.

Gives "a minute description of the routes, scenery, soil, climate, timber, gold, geology, zoology, etc., with an accurate map, four sectional drawings and ten plates from photographs taken on the spot." The book is a delightful narrative of the Newton-Jenney survey of 1875 and contains much information of value to those interested in the early development of the region.

30. MEEK, F. B. A Report on the Invertebrate Cretaceous and Tertiary Fossils of the Upper Missouri Country.

U. S. Geol. Surv. of the Terr., Rept., vol. IX, 629 pp., pl. I-XLV.

Describes and figures many Invertebrate forms collected by Dr. Hayden in the Black Hills region. Preliminary notices of most of these had previously appeared in the Proceedings of the Academy of Natural Sciences of Philadelphia.

1878.

31. MAGUIRE, H. N. The Coming Empire. A Complete and Reliable Treatise on the Black Hills, Yellowstone and Big Horn Regions.

Small 8vo., Sioux City, Iowa, 1878.

A narrative of early history. Gives reasons for supposing that gold was found in the Black Hills as early as 1849.

32. STANTON, CAPT. W. S. Annual Report Upon Explorations and Surveys in the Department of the Platte.

Ann. Rept. Chief Eng., Append. R. R., pp. 1705-1747; pl. 1-14.

An account of explorations in the Black Hills region. Gives a description of routes and includes hypsometric, astronomic and barometric measurements,

1879.

33. COPE, EDWARD D. The Relations of the Horizon of Extinct Vertebrata of Europe and America.

U. S. Geog. and Geol. Surv. of the Terr., Bull., vol. V., No. 1, pp. 33-54.

Includes comparisons and discussions of relations of the White River Tertiary to similar formations elsewhere in America and in

Europe. A diagram is given, showing the proper position, paleontologically considered, of the series of American and European strata.

1880.

34. CASWELL, JOHN H. Microscopic Petrography [of the Black Hills.]

U. S. Geog. and Geol. Surv., Report on the Geology and Resources of the Black Hills of Dakota, pp. 471-537, pls. I-II.

Gives a careful description of the quartzites, mica schists, slates, rhyolites, trachytes, and phonolites of the Black Hills. Eight figures accompanying the report show the microscopic structure of two rhyolites, two phonolites and four sanadine trachytes.

35. COPE, EDWARD D. On the Extinct Cats of America.

Am. Nat., vol. XIV, pp. 833-858.

Describes *Hoplophoneus primaevus* from the White River beds and refers to others from the same locality.

36. JENNEY, WALTER P. Mineral Resources of the Black Hills of Dakota.

U. S. Geog. and Geol. Surv., Report on the Geology and Resources of the Black Hills of Dakota, pp. 225-300.

Paper largely taken up with the consideration of the value and character of the gold deposits. Gives a classification of the deposits and describes the geology and resources of the various mining districts. Concludes that there is gold enough in the Black Hills to cause a thorough settlement of the country.

37. ——— Climate and Resources [of the Black Hills.]

U. S. Geog. and Geol. Surv., Report on the Geology and Resources of the Black Hills of Dakota, pp. 301-324.

Gives a description of the climate, water supply, soil, wild fruits grazing and timber.

38. NEWTON, HENRY. Geology of the Black Hills.

U. S. Geog. and Geol. Surv., Report on the Geology and Resources of the Black Hills of Dakota, pp. 1-222, figs. 1-27, maps.

Report of Geological work done during the year 1875, the paper being edited by Mr. G. K. Gilbert on account of the death of Mr. Newton soon after the completion of the field work. The paper is a comprehensive description of the general geology of the Black Hills, including observations along the routes to and from the Hills. Gives an account of the origin and organization of the Newton-Jenney survey, also a brief sketch of previous explorations in the Upper Missouri region. Discusses the structure of the region, the probable geological history of the Hills, the age of the igneous, metamorphic and sedimentary rocks, together with their manner of formation or deposition and

the relation of the topography and drainage to the structure. Much attention is given to the description of the various formations including their thickness, general character and areal distribution. Numerous excellent structures and columnar sections are given. A large atlas containing a colored geological map, a topographic map and a bird's-eye view of the region, accompanies the complete report.

39. WHITFIELD, ROBERT P. Paleontological Report on the Fossils Collected by the United States Geological and Geographical Survey of the Black Hills.

U. S. Geog. and Geol. Surv., Report on the Geology and Resources of the Black Hills of Dakota, pp. 329-468; pls. I-XVI.

Describes and figures 117 species. Of these thirteen are from the "Potsdam group," thirty-three from the Jurassic and seventy-one from the Cretaceous. A synopsis of species from the Black Hills, noticed in other works but not described in this report, is also given.

1882.

40. COPE, EDWARD D. The Tertiary Formations of the Central Region of the United States.

Am. Nat. Mch., pp. 177-195.

Discusses the topography, structure, stratigraphy and paleontology of the various regions. Much of the information in regard to the White River area is obtained from papers written by Dr. Hayden.

41. ——— Review of the Rodentia of the Miocene Period of North America.

U. S. Geog. and Geol. Surv. of the Terr., Bull., vol. VI, pp. 361-386.

Gives a table showing the distribution of the species of the American Miocene rodentia of which eleven species are represented in the White River beds.

42. DEVEREUX, WALTER B. The Occurrence of Gold in the Potsdam Formation, Black Hills, Dakota.

Am. Inst. Min. Eng., Trans., vol. X, pp. 465-475.

States that the gold occurs as a mechanical and as a chemical constituent. Considers that the deposits, a conglomerate, are ocean sediments laid down on a beach. States that the gold may be called placer gold and the deposits fossil placers. Discusses the condition of deposition and concentration of the gold, the percentage of silver and the probable geological history of events leading up to the formation of the deposits.

43. HAYDEN, FERDINAND V. Report of the Director.

U. S. Geol. Surv., 2d Ann. Rept., pp. 42-44.

Reviews briefly the geology and geological work of the Black Hills region.

44. KING, CLARENCE. Production of the Precious Metals.
U. S. Geol. Surv., 2d Ann. Rept., pp. 337-401. pl. XLVIII-LIII.

Gives the production of gold and silver from the deep mines of Custer, Lawrence and Pennington counties, and the production of gold from the placer mines of Lawrence and Pennington counties for the year ending May 31, 1880.

1883.

45. BLAKE, WILLIAM P. Cassiterite, Spodumene and Beryl in the Black Hills, Dakota.

Am. Jour. Sci., 3d ser., vol. XXVI, p. 235.

Gives a short description of the minerals, their occurrence, and crystallization. Refers particularly to the Etta claim in the Harney Peak district.

46. COPE, EDWARD D. On the Extinct Dogs of North America.

Am. Nat., March, pp.

Mentions *Galecyneus gregarius* as abundant in South Dakota.

47. LESQUEREUX, LEO. Contributions to the Fossil Flora of the Western Territories, Part III, the Cretaceous and Tertiary Floras.

U. S. Geol. Surv. of the Terr., vol. VIII, 233 pp., pls. I-LIX.

Under the head "Description of Miocene species from specimens obtained in the so-called Bad Lands of Dakota," the author describes and figures numerous specimens obtained from Professors Denton, McBride and Winchell. In most cases the exact locality is not given.

48. WILLIAMS, ALBERT, JR. Mineral Resources of the United States.

U. S. Geol. Surv., Min. Res., 8vo., 813 pp.

References to Black Hills resources are given as follows; p. 49, coal; pp. 172-185, gold and silver; p. 528, gypsum; p. 541, salt; p. 583, mica; p. 591, graphite. Page 754 contains a table of ores and minerals of industrial importance mined or known to be present in the Black Hills.

1884.

49. BLAKE, WILLIAM P. Columbite in the Black Hills of Dakota.

Am. Jour. Sci., 3d ser., vol. XXVIII, pp. 340-341.

This is the first notice of columbite from the Black Hills. The author describes the columbite in the Harney Peak district, particularly

at the Etta and the Ingersoll mines. At the latter place a mass approximately 20x30x34 inches and one ton in weight, was found protruding from a matrix of albite and quartz.

50. SCHAEFFER, CHARLES A. A New Tantalite Locality.

Am. Jour. Sci., 8d ser., vol. XXVIII, p. 430.

Gives chemical analysis and specific gravity of tantalite from the Black Hills, associated with scorodite, leucopyrite and olivenite.

51. ——— Note on Tantalite and Other Minerals Accompanying the Tin Ore in the Black Hills.

Am. Inst. Min. Eng., Trans., vol. XIII, pp. 231-233.

Describes specimens from the Etta tin mine and gives a chemical analysis of the tantalite.

1883.

52. BLAKE, WILLIAM P. Tin Ore Veins in the Black Hills, Dakota.

Am. Inst. Min. Eng., Trans., vol. XIII, pp. 691-696.

Discusses the occurrence and associates of the Black Hills cassiterite, the structure of the Etta vein, the percentage of cassiterite in the ore, extent of the tin region and the time of origin of the tin ore and its associates.

53. ——— Tantalite and Columbite in the Black Hills of Dakota.

Am. Inst. Min. Eng., Trans., vol. XIII, pp. 696-697.

Gives observations upon the occurrence of the minerals with the tin ore. States that one mass of columbite or tantalite from the Ingersoll claim weighed approximately two thousand pounds.

54. EMMONS, SAMUEL F. Geological Sketch of the Black Hills of Dakota.

Tenth Census, vol. XIII, Precious Metals, pp. 89-94.

Reviews the geology of the Hills, much of the information being obtained from papers by Professors Newton, Jenney and Devereux. Many Black Hills mineral, their localities and associates are also given.

55. WILLIAMS, ALBERT, JR. Mineral Resources of the United States, Calendar Years 1883 and 1884.

U. S. Geol. Surv., Min. Res., 8vo., 1016 pp.

References to Black Hills resources are given as follows: pp. 819-821, gold and silver; pp. 602-618, tin; p. 812, gypsum; p. 848, salt,

pp. 909-910, mica; p. 913, asbestos; p. 980, mineral waters. The report on tin by Mr. W. P. Blake, gives an excellent account of the geology and development of the Black Hills tin districts.

1886.

56. WHITE, CHARLES A. On the Fresh Water Invertebrates of the North American Jurassic.

U. S. Geol. Surv., Bull. 29, pp. 1-24, pls. I-IV.

Gives descriptions and figures of certain specimens previously described by Meek and Hayden. Refers to these forms in a discussion of the probable physical geography of the region during the Jurassic period.

57. WILLIAMS, ALBERT, JR. Mineral Resources of the United States, Calendar Year 1885.

U. S. Geol. Surv., Min. Res., 8vo, 576 pp.

References to Black Hills resources are given as follows: pp. 200-207, gold and silver; p. 370, tin; p. 518, mica.

1887.

58. DAY, DAVID T. Mineral Resources of the United States, Calendar Year 1886.

U. S. Geol. Surv., Min. Res., 8vo., 813 pp.

References to Black Hills resources are given as follows: pp. 104-108, gold and silver; p. 140, lead; p. 214, tin; p. 548, building stone; pp. 622-623, gypsum.

59. MARSH, OTHNIEL C. Notice of New Fossil Mammals.

Am. Jour. Sci., 3d ser., vol. XXXIV, pp. 223-331.

Describes *Brontops dispar*, *Menops varians*, *Titanops elatus* and *Allops serrotinus* from the Miocene of Dakota.

1888.

60. CARPENTER, FRANKLIN R. Notes on the Geology of the Black Hills.

Dak. Sch. Mines, Prelim. Rept., pp. 1-52, map.

Gives a general description of the geology of the region. Discredits the theory that the granites are eruptive. Announces the discovery of prominent conglomerates in the pre-Cambrian rocks and mentions the presence of a dike of igneous rocks, provisionally classed as diorite, also in the pre-Cambrian. Discusses the geological history of the Hills. Considers that the Purple Limestone is a chemical precipitate. Refers to the "volcanic plugs or necks" of the Northern Hills

and suggests the apparently true laccolitic nature of some of the intrusions. A colored geological map, slightly revised from Newton's map, accompanies the paper.

61. ——— The Mineral Resources of the Black Hills, their Character, Occurrence and Extent.

Dak. Sch. Mines, Prelim. Rept., pp. 107-171.

Deals mostly with the occurrence and production of gold, silver, copper, nickel, tin, and structural materials. Classifies and describes the auriferous deposits and describes methods of treating the ore. Discusses the occurrence and association of the cassiterite and suggests methods of treatment. Numerous tests are given showing the percentage of black tin in the rock.

62. CROSBY, WILLIAM O. Quartzites and Siliceous Concretions.

Tech. Quart., May, pp. 397-407.

Paper suggested by certain phenomena observed on Box Elder creek. Notes the very variable nature of the lower beds of the "Potomac," it being calcareous, glauconitic, a normal sandstone, a conglomerate or a firm quartzite. Mentions dikes connecting the intrusive sheets. Divides the quartzites of the Black Hills into two divisions: those associated with igneous rocks and the quartzites beyond the influence of volcanic action. Discusses the probable two-fold origin of the cementing silica.

63. ——— Geology of the Black Hills of Dakota.

Bost. Soc. Nat. Hist., Proc., vol. XXIII, pp. 488-517.

Describes the rocks and discusses the structure and the history of the region. Thinks with Newton that the pre-Cambrian rocks may be divided into two groups, viz.: an older or Western series and a younger or Eastern series. Describes the conglomerate of the Eastern series, which previously had not been observed. Concludes that true eruptive granite is probably entirely wanting in the Black Hills, but that it is of the nature of segregated veins. Gives the probable relation of the cones, sheets and dikes in the Northern Hills, shows the presence of true laccolites and discusses the cause of the boulder cap surrounding the Hills.

64. DAY, DAVID T. Mineral Resources of the United States, Calendar Year 1887.

U. S. Geol. Surv., Min. Res., 8vo, 832 pp.

References to Black Hills Resources are given as follows: pp. 58-63, gold and silver; p. 110, lead; pp. 134-136, tin; p. 661, mica.

Pages 716-718 contain a table of ores and minerals of industrial importance mined or known to be present in the Hills.

1889.

65. MARSH, OTHNIEL C. Restoration of Brontops Robustus from the Miocene of America.

Am. Jour. Sci., 3d ser., vol. XXXVII, pp. 163-165, pl. VI.

Describes this as belonging to the largest group of mammals in the American Miocene, the skeleton of which was found in the White River beds in 1874. States that the Brontotheridae to which the Brontops belongs nearly equalled in size the existing elephant, that it belongs to the distinct order of perissodactyles and that it is more nearly allied to the rhinoceros than to any other living form.

66. WARD, LESTER F. The Geological Distribution of Fossil Plants.

U. S. Geol. Surv., 8th Ann. Rept., part II, pp. 669-960, pl. LXL.

Refers on pp. 903-904 to collections of fossil plants from the Black Hills region.

67. WARREN, LIEUTENANT G. K. Memoir Giving a Brief Account of Each of the Exploring [erroneously printed "English,"] Expeditions [West of the Mississippi River] Since A. D. 1880.

U. S. Geog. Surv., vol. I, Geog. Rept., pp. 513-597, map.

This is a brief and excellent account of the many exploring expeditions sent out by the government previous to the year 1857. The routes of several of the Black Hills expeditions are given, also the methods employed in making observations as well as titles of publications resulting from the work done.

68. WHEELER, GEORGE M. Explorations and Surveys [West of the Mississippi River], 1857-1800.

U. S. Geog. Surv., vol. I, Geog. Rept., pp. 599-745, map.

This paper is a continuation of the memoir by Lieutenant Warren, published in the same report, and the general character of the two papers is identical.

1890.

69. CHANCE, H. M. The Resources of the Black Hills and Big Horn Country, Wyoming.

Am. Inst. Min. Eng., Trans., vol XIX, pp. 49-58.

Gives the results of an examination made in 1887-88 of the country lying between the Black Hills and the Big Horn mountains. Refers

briefly to the structure, resources and scenery of the Hills. States that the oil and coal deposits near Newcastle are in the Dakota sandstone.

70. CLARK, FRANK W. Report of Work Done in the Division of Chemistry and Physics.

U. S. Geol. Surv., Bull. No. 60, 174 pp.

Gives on pages 135-136 an analysis of Triplite from "a tin mine near Rapid City," as determined by L. G. Eakins.

71. DAY, DAVID T. Mineral Resources of the United States, Calendar Year 1888.

U. S. Geol. Surv., Min. Res., 8vo, 652 pp.

References to Black Hills resources are given as follows: pp. 36-22, gold and silver; pp. 144-156, tin.

72. HEADDEN, WILLIAM P. Columbite and Tantalite from the Black Hills.

Col. Sci. Soc., Proc., vol. III, pt. III, pp. 323-346.

Notes that all of the Black Hills columbites are rich in manganese. Gives the chemical composition and specific gravity of columbite from seventeen different Black Hills localities. Discusses the physical characters and associations of specimens from the Etta tin mines, the chief source. Gives also a description and two analyses of manganese columbite from the Advance claim, one and one-half miles south of the Etta mine.

This paper with some additions appeared in the American Journal of Science for 1891.

73. ——— Notes on the Discovery and Occurrence of Tin Ore in the Black Hills, S. D.

Col. Sci. Soc., Proc., vol. III, pt. III, pp. 347-350.

States that the earliest identification of tin from the Black Hills was in 1876 by Mr. Richard Pearce, of Denver, Colorado, who detected cassiterite as stream tin in gold dust from the Northern Hills. The second discovery was made on Elk gulch, southern section, in April, 1877. The material from the latter place was assayed by Theodore Vosburg, but the true nature of the bullion was first recognized by Mr. Fred J. Cross. Dates of various other discoveries and remarks on the general geology of the region are also given.

74. MARSH, OTHNIEL C. Notice of New Tertiary Mammals.

Am. Jour. Sci., 3d ser., vol. XXXIX, pp. 523-525

Describes from the "Miocene Brontotherium beds" of the White

River basin: *Diploconus amplius*, *Teleodus avus*, *Colodon luxatus*, *Hypotamius depectus*, *Limnohyops laticeps*.

75. ——— Notice of Some Extinct Testudinata.

Am. Jour. Sci., 3d ser., vol. XL, pp. 177-179, pls. VII-VIII.

Describes the new species *Testudo brontops* from the Lower Miocene of South Dakota, which includes the largest American tortoises known, either living or extinct. States that some specimens observed in the field are surpassed in size only by the gigantic forms from the Pliocene of India.

76. ——— Description of New Dinosaurian Reptiles.

Am. Jour. Sci., 3d ser., vol. XXXIX, pp. 81-86.

Describes portions of the new species and genus *Barosaurus lentus* and figures a caudal vertebra from Piedmont, South Dakota.*

77. VAN HISE, CHARLES R. The Pre-Cambrian Rocks of the Black Hills.

Geol. Soc. Am., Bull., vol. I, pp. 203-255, pls. 4-5.

States that the slates and schists cannot be divided into two series as given by Newton. Indicates two areas of crystalline schists, the larger lying as a broad zone about the granite, the other in the vicinity of Deadwood. Concludes with Newton that the main mass of the granite is eruptive and that the basic eruptive rocks are older than the granite. Reviews briefly the probable pre-Cambrian history of the Hills. Considers that the quartzites, quartz schists, mica slates, mica schists, and certain of the mica gneisses are of clastic origin, while most or all of the hornblende and chloritic schists are eruptive; that in the original detritus of the micaceous rocks feldspar and quartz were the predominant minerals, but that the detritus of the quartzites and quartz schists contain little feldspar. States that the pre-Cambrian rocks resemble the Huronian iron-bearing series of the Lake Superior region and that they are of undoubted Algonkian age.

78. WALCOTT, CHARLES D. The Fauna of the Lower Cambrian or Olenellus Zone.

U. S. Geol. Surv., 10th Ann. Rept., pp. 515-763, pls. XLIII-XCVIII.

Discusses the Black Hills Cambrian rocks in their relation to other Cambrian areas of North America.

*For this statement of locality see the American Journal of Science, March, 1899, p. 228.

1891.

79. BLAKE, WILLIAM P. Columbite of the Black Hills.
 Am. Jour. Sci., vol. XLI, pp. 403-405.
 Describes specimens from the Etta and Bob Ingersoll mines and gives measurements and three figures by Professor S. L. Penfield.
80. CLARK, FRANK W. Report of Work Done in the
 Division of Chemistry and Physics.
 U. S. Geol. Surv., Bull. No. 78. 129 pp.
 Gives on p. 120 an analysis of a mineral from the Brown tin mine, supposed to be Liebnerite. Analyzed by W. F. Hillebrand and E. L. Howard.
81. GANNETT, HENRY. A Dictionary of Altitudes in the
 United States (second edition).
 U. S. Geol. Surv., Bull. No. 76. 393 pp.
 Gives the altitudes of a number of points in the Black Hills and the authority for the same.
82. HEADDEN, W. P. and PIRSSON, L. V. On Black Rutile
 from the Black Hills.
 Am. Jour. Sci., vol. XLI, pp. 249-250.
 Describes crystals from the Harney Peak district. One figure and two chemical analyses are given.
83. HEADDEN, WILLIAM P. A New Phosphate from the
 Black Hills of South Dakota.
 Am. Jour. Sci., 3d ser., vol. XLI, pp. 415-417
 Gives the physical characters and five chemical analyses of a new phosphate found at the Riverton lode near Harney City, for which the author proposes the name griphite in allusion to its unusual and somewhat enigmatical composition. A phosphate from the Nickel Plate tin claim closely related to Triphylite is also described and two chemical analyses given.
84. MARSH, OTHNIEL C. Geological Horizons as Determined by Vertebrate Fossils.
 Am. Jour. Sci., 3d ser., vol. XLII, pp. 336-338, pl. VII.
 Mentions the presence of Baptonodon beds in South Dakota.
85. ——— Notice of New Vertebrate Fossils.
 Am. Jour. Sci., 3d ser., vol. XLII, pp. 265-269.
 The following new species of Brontotheridae are described from

the White River beds: *Allops crassicornis*, *Brontops validus*, *Titanops medius*.

86. ——— A Horned Artiodactyle (*Protoceras celer*) from the Miocene.

Am. Jour. Sci., 8d ser., vol. XLI, pp. 81-82.

Gives a short description of this the first horned artiodactyle found in the Miocene. Is apparently a true ruminant and nearly as large as a sheep. Found in the upper part of the *Oreodon* beds of the White River basin.

87. THOMPSON, A. H. Administrative Report.

U. S. Geol. Surv., 12th Ann. Rept., pp. 42-52.

Gives on p. 49 an account of astronomical work at Rapid City as a preliminary to future topographic work.

88. WALCOTT, CHARLES D. The Cambrian Group of Rocks in North America.

U. S. Geol. Surv., Bull. 81, Correlation Papers, 447 pp., pls. I-III.

The author reviews on pages 214-216 the results of previous workers in the Black Hills region and on pages 347-349 describes the Black Hills Cambrian as given by Newton, Carpenter and others. The Black Hill region is represented on the maps which show the distribution, relative thickness, etc., of the rocks in the various provinces. The paper by Mr. Edwin James, also the one by Mr. H. Englemann quoted as referring to the Black Hills of Dakota, refer instead to the Laramie mountains, lying within the forks of the Platt river in Wyoming, formerly known as the Black Hills of Wyoming.

89. ——— The North American Continent During Cambrian Time.

U. S. Geol. Surv., 12th Ann. Rept., pp. 529-568, pls XLII-XLV,

Discusses the Black Hills Cambrian area in its relation to other Cambrian areas of North America.

90. WHITE, CHARLES A. A Review of the Cretaceous Formations of North America.

U. S. Geol. Surv., Bull. No. 82, Correlation Papers, 273 pp., pls. I-III.

Makes frequent general mention of the Cretaceous rocks in and around the Black Hills region.

91. WILLIAMS, HENRY S. The Devonian and Carboniferous Formations of North America.

U. S. Geol. Surv., Bull. No. 80, Correlation Papers, 279 pp.

Refers briefly to the Black Hills formations as made out by Meek and Hayden.

1892.

92. CLAYPOLE, E. W. The Tin Island of the Northwest. Am. Geol., vol. IX, pp. 228-236.

Discusses the general geology of the region with particular reference to the pre-Cambrian rocks. Describes the occurrence of cassiterite and discusses its probable economic importance.

93. DALL, W. H. and HARRIS, G. D. The Neocene of North America.

U. S. Geol. Surv., Bull., No. 84, Correlation Papers, 349 pp.

Describes the White River Miocene chiefly as given by Hayden and Leidy.

94. DAY, DAVID T. Mineral Resources of the United States, Calendar Years 1889 and 1890.

U. S. Geol. Surv., Min. Res., 8vo., 671 pp.

References to Black Hills resources are given as follows: pp. 48-55, gold and silver; p. 80, lead; pp. 119-123, tin; p. 429, sandstone; pp. 465-466 gypsum; p. 474, mica; p. 532, mineral waters.

95. OSBORN, H. F. and WORTMAN, J. L. Characters of Protoceras (Marsh) the New Artiodactyle from the Lower Miocene.

Am. Mus. Nat. Hist., Bull., vol. IV, pp. 351-371, figs. 1-6.

Describes the characters of the species with especial reference to specimens recently found in the White River beds. Discusses the systematic position of the genus and gives a table showing in condensed form the principal characters of the family Protoceratidae with those of the families of the Tragulina and the Pecora.

96. THOMPSON, A. H. Administrative Report.

U. S. Geol. Surv., 13th Ann. Rept., pp. 75-83.

Gives on page 79 an account of topographic work done in the vicinity of Rapid City and Deadwood during the summer of 1891.

97. ULKE, TITUS. A New Tin Mineral in the Black Hills. Am. Inst. Min. Eng., Trans., vol. XXI, pp. 240-241.

Describes a mineral from the Etta mine containing both copper and tin, to which the name cuprocassiterite is given.

98. VAN HISE, CHARLES R. A Review of the Present State of Knowledge of the Pre-Cambrian Rocks of North America.

U. S. Geol. Surv., Bull. No. 86, Correlation Papers, Archaean and Algonkian, 549 pp., pls. I-XII.

Refers to the Black Hills on pages 257-261, 270 and 503. Gives a short digest of the literature on the Black Hills Algonkian rocks and the conclusions that may be drawn from the work done. Plate VII shows the position of the Algonkian rocks of the Black Hills as related to other North American areas.

99. WALCOTT, CHARLES D. Preliminary Notes on the Discovery of a Vertebrate Fauna in Silurian (Ordovician) Strata.

Geol. Soc. Am., Bull., vol. III, pp. 153-173.

In a footnote on page 173 the author mentions the receipt from Professor F. R. Carpenter of specimens of *Maclurea logani* and *Endoceras accumulatum* collected in the Black Hills, thus establishing the presence of the Trenton in this region.

1893.

100. CLARK, WILLIAM B. The Mesozoic Echinodermata of the United States.

U. S. Geol. Surv., Bull. No. 97, 207 pp., pls. I-L.

Describes and figures a few forms from the Black Hills previously described by others.

101. COUES, ELIOT. History of the Expedition Under the Command of Lewis and Clark, etc.*

Four volumes, 8vo. New York, 1893.

Refers briefly to the topography, climate and geography of the Black Hills region and locates the mountainous area as a single ridge extending from the South Fork of the Cheyenne to a point far beyond the North Fork.

102. DAY, DAVID T. Mineral Resources of the United States, Calendar Year 1891.

U. S. Geol. Surv., Min. Res., 8vo, 630 pp.

Refers to Black Hills mineral resources as follows: pp. 74-80, gold and silver; p. 137, manganese; p. 164, tin; pp. 168-169, nickeliferous pyrrhotite; pp. 580-582, gypsum.

*A number of histories, reports and narratives of this expedition have been issued at different times by various individuals. I have referred only to this one by Professor Coues because it is the best and most recent that has come to my notice.

103. ——— Mineral Resources of the United States, Calendar year 1892.

U. S. Geol. Surv., Min. Res., 8vo, 850 pp.

Refers to Black Hills mineral resources as follows: pp. 50-56 and 69-71, gold and silver; p. 258, tin; p. 749, grindstones.

104. FINLEY, JOHN P. Certain Climatic Features of the Two Dakotas.

Large 8vo, 206 pp., 163 tables, charts and diagrams, Washington. Makes frequent reference to the climate of the Black Hills region.

105. GANNETT, HENRY. The Average Elevation of the United States.

U. S. Geol. Surv., 13th Ann. Rept., pp. 284-289.

Refers to the height of the Black Hills region.

106. HATCHER, J. B. The Titanotherium Beds.

Am. Nat., March 1 1893, pp. 203-221.

Discusses the origin and authenticity of the name of the beds, their geographical distribution, lithological character, method of deposition of the sediments and the cause of the numerous vertical veins of chalcedony. Notes the finding of a small Miocene deposit near Lead City by Professor W. P. Jenney. States that during the seasons of 1886, '87, '88 the author spent fifteen months in the White River Miocene beds of South Dakota and Nebraska, making extensive collections, the study of which resulted in a separation of the Titanotherium beds into the Lower, Middle and Upper divisions. The most noticeable change in the Titanotherium skeletons is a gradual and decided increase in size from the lowest to the highest beds. A section of the beds accompanies the paper, showing the relative thickness of the three beds with brief descriptions of forms of Titanotheridae characteristic of each.

107. HEADDEN, WILLIAM P. Stannite and Some of the Alteration Products from the Black Hills, S. D.

Am. Jour. Sci., 3d ser., vol. XLV, pp. 105-110.

Gives physical characters and chemical analyses of minerals from the Peerless and Etta mines.

108. ——— Kehoeite, a New Phosphate from Galena, Lawrence County, S. D.

Am. Jour. Sci., 3d ser., vol. XLVI, pp. 22-24.

Describes an argentiferous galena carrying zinc blende and iron pyrite from the Merritt mine. States that goslarite also occurs in the mine, but not in the immediate vicinity of the Kehoeite. The physical characters and three chemical analyses are given. Named from Mr.

Henry Kehoe, who first observed the occurrence of the mineral. The article includes a "Note on Jarosite," found at the Buxton mine, Lawrence county. One chemical analyses of the latter mineral is given.

109. MCBRIDE, T. H. A New Cycad.

Am. Geol., vol. XII, pp. 248-250.

Describes Bennetites from near Minnekahta, South Dakota.

110. MARSH, OTHNIEL C. Description of Miocene Mammalia.

Am. Jour. Sci., 3d ser., vol. XLVI, pp. 407-412, pls. VII-X.

Describes various species of mammals, among which are the following from the White River basin: *Elotherium crassum*, *E. clavum*, *Ammodon (Elotherium) bathrodon*, and *Colodon luxatus*.

111. OSBORNE, HENRY F. Rise of the Mammalia in North America.

Am Jour. Sci., 3d ser., vol. XLVI, pp. 448-466, pl. XI. Continued from p. 892.

Reviews the history of previous study of the Mammalia, discusses the classification and gives a table showing the succession of the North American mammals. Various Tertiary types from the White River Miocene are cited.

112. ——— *Aceratherium Tridactylum* from the Lower Miocene of Dakota.

Am. Mus. Nat. Hist., Bull., vol. V, pp. 85-86.

Gives a preliminary description of the fossil named.

113. OSBORNE, H. F. and WORTMAN, J. L. *Artionyx*, a New Genus of Ancylopoda.

Am. Mus. Nat. Hist., Bull., vol. V, pp. 1-18.

Describes a specimen from the Protoceras beds of the White River Miocene. Compares the type with other forms, gives a table of the double parallelism of the *Artionychia* and *Perissonychia* and discusses the affinities of the Ancylopoda.

114. POSEPNY, F. The Genesis of Ore Deposits.

Am. Inst. Min. Eng., Trans., vol. XXIII, pp. 197-369.

Mentions the "hysteromorphous deposits" of the Cambrian in the Northern Hills. Refers especially to the paper by Mr. Devereux.

115. STANTON, TIMOTHY W. The Colorado Formation and its Invertebrate Fauna.

U. S. Geol. Surv., Bull. No. 106, 128 pp., pls. I-XLV.

Refers frequently to the geology of the Black Hills region, quoting from previous papers. Describes and figures various fossils collected by others in the vicinity of the Hills.

116. THOMPSON, A. H. Administrative Report.

U. S. Geol. Surv., 14th Ann. Rept., pp. 175-182.

Refers on p. 178 to the survey of the Hermosa quadrangle.

117. WORTMAN, J. L. On the Divisions of the White River or Lower Miocene of Dakota.

Am. Mus. Nat. Hist., Bull., vol. V. pp. 95-105.

Announces the differentiation of the Protoceras beds formerly considered as the upper part of the Oreodon beds. Describes the lithologic character and the fauna of the Lower Miocene beds, gives a stratigraphic table of the formations and reviews the faunal distribution and succession of types.

118. WORTMAN, J. L. and EARLE, CHARLES. Ancestors of the Tapir from the Lower Miocene of Dakota.

Am. Mus. Nat. Hist., Bull., vol. V, pp. 159-180, figs. 1-7.

Announces the discovery of the occurrence of Protapirus in the upper part of the White River Miocene, thus placing the origin of the true tapirs in this country below the Oreodon beds and nearly parallel stratigraphically with the European species of Protapirus. Discusses the various attempts which have been made to solve the problem of the origin of the tapir in America. Gives a systematic description of the material relating to the American species of Protapirus and Colodon; also a review of the relationship between the American species of Protapirus and those found in Europe, including a resume of the principal characters of the supposed Eocene ancestors of both the Tapiridae and Helaletidae.

1894.

119. CALVIN, SAMUEL. On the Geological Position of *Bennetites dacotensis* Macbride, with Remarks on the Stratigraphy of the Region in which the Species was Discovered.

Ia. Acad. Sci., Proc., vol. I. pt. IV. pp. 18-22. Published also in Am. Geol., Feb. 1894, pp. 79-84.

Gives a detailed discussion of the geological and geographical position of the cycads found in the Southern Black Hills and concludes that *Bennetites dacotensis* belongs to the Cretaceous period and that the horizon which contains the cycads is probably in the uppermost layer of the Dakota sandstone.

120. DAY, DAVID T. Mineral Resources of the United States, Calendar year 1893.

U. S. Geol. Surv., Min. Res., 8vo., 810 pp.

References to Black Hills resources are given as follows: pp. 50-61, gold and silver; p. 182, manganese; pp. 713-716, gypsum. In the

report on gold and silver a table is given in which is indicated the production of gold and silver in the Black Hills during the years 1881-1891.

121. GANNETT, HENRY. Results of Primary Triangulation.

U. S. Geol. Surv., Bull. No. 122, 412 pp., pl. XVII.

Contains on pp. 279-286 and pl. IX an account of work done in the Black Hills under the direction of Mr. E. M. Douglas. Descriptions and positions of the following stations are given: Bear Butte, Custer Peak, Piedmont, Costello, Mitchell, West Base, White, Astronomical Pier in Rapid City court house yard, Sammis, East Base, Dunning, Harney Peak, Thompson Butte, Cheyenne, Gap, Bradley, Fossil, Windy, State Line.

122. HATCHER, J. B. Discovery of *Diceratherium*, the two-horned Rhinoceros, in the White River Beds of South Dakota.

Am. Geol., vol. XIII, pp. 360-361.

Describes *Diceratherium proavatum* obtained by the Princeton party in 1894, from the Upper Oreodon (*Protoceras*) beds.

123. KNOWLTON, F. H. Fossil Wood from the Black Hills, South Dakota.

Jour. Geol., vol. II, pp. 260-261. [Not seen.]

Describes the structure of the wood of genus *Araucarioxylon*. [W. 135.]

124. MARSH, OTHNIEL C. Eastern Division of the Miohippus Beds, with Notes on some of the Characteristic Fossils.

Am. Jour. Sci., 3d ser., vol. XLVIII, pp. 91-94.

Refers to the White River Miocene as including the *Miohippus* beds, now generally known in South Dakota as the *Protoceras* beds.

125. ——— Miocene Artiodactyles from the Eastern *Miohippus* Beds.

Am. Jour. Sci., 3d ser., vol. XLVIII, pp. 175-178.

Describes and figures remains of *Heptacodon gibbioeps*, *Elomeryx armatus* and *Octacodon volens* from the White River Miocene.

126. ——— Description of Tertiary Artiodactyles.

Am. Jour. Sci., 3d ser., vol. XLVIII, pp. 259-274.

Among those given the author describes *Agriomeryx migrans* and *Leptochoerus gracilis* from the White River Miocene.

127. ——— A New Miocene Tapir.

Am. Jour. Sci., 3d ser., vol. XLVIII, p. 348.

Describes a pair of lower jaws found in the *Miohippus* beds of

South Dakota, which represents an ungulate mammal, probably an ancestor of the modern tapir. The name suggested is *Tanyops indans*.

128. MCBRIBE, THOMAS H. North American Cycads.

Ia. Acad. Sci., Proc., vol. I, pt. IV, pp. 62-65.

Includes a short general discussion of cycads and an account of the development of our knowledge of them in the United States. Refers particularly to the Black Hills cycads and to the manner of learning of their presence there.

129. OSBORN, H. F. and WORTMAN, J. L. Fossil Mammals of the Lower Miocene White River Beds. Collection of 1892.

Am. Mus. Nat. Hist., Bull., vol. VI, pp. 199-228, pls. II-III, figs. 1-8.

The paper is based on collections made during the year 1892. The chief points presented are: New characters of the Lower Miocene rhinoceroses, the osteology of *Metamynodon*, the basi-occipital characters of *Oreodon* as developed in successive horizons, the determination of two species of *Anthracotherium*, and additional characters of the American *Hyopotamus*. A table showing the succession of species in the White River Miocene is also given.

130. PEALE, A. C. The Natural Mineral Waters of the United States.

U. S. Geol. Surv., 14th Ann. Rept., pp. 53-88.

Mentions the Dakota hot springs [Hot Springs, S. D.]

131. PIRSSON, LOUIS V. Phonolitic Rocks from the Black Hills.

Am. Jour. Sci., 3d ser., vol. XLVII, pp. 341-346.

Refers to the information at hand concerning the phonolite of the Black Hills and describes two specimens given the author by individuals who had made little or no observations of field relations. One specimen came from near Deadwood, the other from the Devils Tower. Closes with an earnest suggestion as to the value of further study of the region.

132. SCOTT, WILLIAM B. Notes on the Osteology of *Agriochoerus* Leidy (*Artionyx* O. and W.)

Am. Phil. Soc., Proc., vol. XXXIII, pp. 242-251. [Not seen.]

Describes and figures fragmentary skeletons from the White River bad lands of South Dakota and discusses the systematic position of the genus, (W. 135).

133. ——— Notes on the Osteology of *Ancodus* (*Hyopotamus*).

Geol. Mag., dec. IV, vol. I, pp. 492-493. [Not seen].

Describes the principal characteristics of *Ancodus brachyrhyn-*

chus from material found in the Tertiary beds of South Dakota. (W. 135).

134. TODD, JAMES E. A Preliminary Report on the Geology of South Dakota.

South Dakota Geol. Surv., Bull. No. I, 173 pp. pl. I-V, figs 1-2.

Gives an excellent summary description of the topographic and geologic features of the state including a discussion of the origin, distribution and character of the igneous, metamorphic and sedimentary rocks. An account of the economic geology, a preliminary geological map and a table of the geological formations of the state are also given. Much attention is paid to the geology in the Black Hills region.

- 135: WARD, LESTER, F. The Cretaceous Rim of the Black Hills.

Jour. Geol. vol. II, pp. 250-266.

Gives a sketch map of the southern foothills, showing locality of cycads near Minnekahta, also various columnar sections and figures. Refers to leaf impressions and silicified wood found at several localities. States that the structure of the wood is well preserved and that it represents apparently an undescribed species of *Aravcarioxylon*. Certain plant forms obtained from the plant beds above Evans quarry are named and are stated to belong apparently to the Dakota group. All plants found below this horizon distinctly indicate a Lower Cretaceous age. The author points out the uncertainty of the dividing line between the Upper and the Lower Cretaceous and discusses the bearing of the facts presented upon the Lower Cretaceous of North America.

136. ——— Fossil Cycadean Trunks of North America with a Revision of the Genus *Cycadeoidea* Buckland.

Biol. Soc. Wash., Bull., vol. IX, pp. 75-87.

Refers to the recent discovery of cycads in the Cretaceous rim of the Black Hills and of its stimulus to the study of these forms in America. Refers briefly to other cycad regions of America and mentions particular localities in the Black Hills. In the revision of the genus *Buckland* the author gives a bibliography of the genus to which genus apparently all of our American forms belong.

1898.

137. CASE, E. C. On the Mud and Sand Dikes of the White River Miocene.

Am. Geol., vol. XV, pp. 248-254.

Reviews the descriptions of dikes of this character in California, Nebraska and South Dakota. Concludes that the dikes of the White River bad lands occupy pre-existing cracks, which were filled with intrusions of water and suspended materials from below; that the cracks are mud cracks and cracks formed by segregation of the clays around

local centers; that the veins of Chalcedony were formed by the entrance of silicated waters into cracks of similar origin as those containing the dikes; and that the thinning out of the seams from above downward indicates that the silicated waters filtered in from above.

138. GANNETT, HENRY A. A Dictionary of Geographic Positions in the United States.

U. S. Geol. Surv., Bull. No. 123, 183 pp., pl. I.

Gives on p. 121 the latitude and longitude of various places in the Black Hills and the authority for the same.

139. MIDDLETON, JEFFERSON. Statistics of the Clay-Working Industries of the United States.

U. S. Geol. Surv., 16th Ann. Rept., part IV, Min. Res. pp. 517-575.

Gives on pp. 553-559, 568-569, 572-573 analyses of fireclay, brick-clay and terra cotta clay from Rapid City.

140. OSBORN, H. F. and WORTMAN, J. L. Perissodactyles of the Lower Miocene White River Beds.

Am. Mus. Nat. Hist., Bull., vol. VII, pp. 343-375; pls. VIII-XI, figs. 1-12.

Describes and figures almost entire skeletons of *Titanotherium robustum* and *Metamynodon planifrons*. States that the White River horses exhibit a very marked evolution in size from the lower to the higher beds, shows that the true *Lophiodontidae* of Europe are found to be represented in this country by the *Heptodon*-*Helaletes*-*Colodon* line previously referred to the *Helaletidae* and indicates the differences between the *Tapir*, *Lophiodon*, and *Hyracus* molar types. A table indicates the stratigraphical position of the species described.

141. PARKER, EDWARD W. Gypsum.

U. S. Geol. Surv., 16th Ann. Rept., part IV, Min. Res., pp. 662-666.

Gives on p. 664 the production of gypsum from South Dakota [Black Hills] for the years 1889, '90, '91, '93, '94.

142. PEARCE, DR. RICHARD. Occurrence of Tellurium in Oxidized Form Associated with Gold.

Col. Sci. Soc., Proc., vol. V. pp. 144-147.

Announces the discovery of tellurium in what is commonly called the Potsdam ore of the Black Hills. Quotes from a letter written by Professor F. C. Smith, who furnished the specimens of ore. Gives a short description of the ore with two analyses, one of oxidized, the other of unoxidized material, showing amounts of gold, silver and tellurium present.

143. ROLKER, CHARLES M. The Production of Tin in Various Parts of the World.

U. S. Geol. Surv., 16th Ann. Rept., part III, Min. Res., pp. 458-538,

Gives on pages 530-535 a brief review of the development of the tin mines in the Black Hills and of the geology of the tin-bearing districts.

144. ROSEN, REV. PETER. Pahasapah or the Black Hills of South Dakota.

8vo, 645 pp., St. Louis, 1895,

Gives an account of the early history of the Hills. Makes extended references to some of the early expeditions to the region and includes a paper by Professor Franklin R. Carpenter on the Mineral Resources. Refers to some of the writings of Father DeSmet, the Jesuit missionary who visited the Indians in the Black Hills region in the years 1847, 1848, 1851 and 1864, and who is supposed by some to have known of the presence of gold in the Hills several years before it was positively announced by others. Mentions the early establishment of a trading post near where Smithville now stands.

145. SCOTT, WILLIAM B. The Osteology and Relations of Protoceras.

Jour. of Morph., vol. XI, pp. 303-374, pls. XX-XXII. [Not seen.]

Describes the dentition, brain, vertebral column, and limbs of Protoceras, discusses its systematic position, and describes and figures a restoration of Protoceras celer, (W. 146).

146. ——— A Restoration of Hyenodon.

Geol. Mag., dec. IV, vol. II, pp. 441-443, pl. XIIa. [Not seen].

Describes briefly the character of Hyenodon Cruentus, Leidy, from the White River beds of South Dakota, (W. 146).

147. THOMPSON, A. H. Administrative Report.

U. S. Geol. Surv., 15th Ann. Rept., pp. 119-129.

Gives on pages 123-124 an account of topographic work done in the Black Hills region. This includes certain triangulation work, the careful measurement of a base line near Rapid City, and the survey of the Harney Peak and the Oelrich quadrangles.

148. TODD, JAMES E. Recent Geological Work in South Dakota.

Am. Geol., vol. XVI, p. 202.

Gives a short account of field work done in the Black Hills region during the summer of 1895. A fuller account of this work is given in the several papers published in Bulletin No. 2 of the State Geological Survey. See 1898.

149. WALCOTT, CHARLES D. Report of the Director.

U. S. Geog. Surv., 16th Ann. Rept., pp. 7-180.

Refers on p. 41 to a collection of fossil plants obtained by Dr. W. P. Jenney from the Lower Cretaceous of the Black Hills.

150. WARD, LESTER F. Some Analogies in the Lower Cretaceous of Europe and America.

U. S. Geol. Surv., 16th Ann. Rept., pp. 469-542, pls. XCVII-CVII.

Refers to the Lower Cretaceous of the Black Hills and describes and figures a number of cycads obtained from the region. Notes also the Aravcarian structure of specimens of fossil wood from here.

151. WEEKS, JOSEPH D. Manganese.

U. S. Geol. Surv., 16th Ann. Rept., part III, Min. Res., pp. 389-457.

Refers on p. 423 to the production of manganese in Custer county, and gives one analysis.

152. WORTMAN, J. L. On the Osteology of Agriochaerus.

Am. Mus. Nat. Hist., Bull., vol. VII, pp. 145-178.

Paper based on fossils from the White River Miocene. Presents an account of the osteology of the Agriochaerus together with a critical review of the species which have been described as belonging to it. Gives careful comparisons of Agriochaerus with Oreodon and shows its similarity to the Anoplotheridae. Considers it as an apparent member of the Artiodactyla. Gives a table, modified from Professor Cope, showing the analysis of the species and one plate showing restoration of Agriochaerus latifrons.

1896.

153. ADAMS, GEORGE I. The Extinct Felidae of North America.

Am. Jour. Sci. 4th ser., vol. I, pp. 419-444, pl. X-XII.

Summarizes the literature on the extinct felidae, adds much new information and proposes a classification for the family. In the White River Miocene the Titanotherium beds furnished one species Dinictis fortis; the Oreodon beds eight, Dinictis felina; D. fortis, D. squalidens, Hoplophoneus occidentalis, H. oreodontis, H. robustus, H. insolens, H. primaevus; and the Protoceras beds two—Dinictis felina and Hoplophoneus insolens.

154. BEECHER, CHARLES E. Occurrence of Silurian Strata in the Big Horn Mountains, Wyoming and in the Black Hills, South Dakota.

Am. Geol., vol. XVIII, pp. 81-83.

Mentions a visit in 1889 to the Trenton area a few miles southeast

of Deadwood and refers to the fossils mentioned by Mr. Walcott in footnote of Geol. Soc. Am. Bull. vol. III, p. 163. Announces also the presence of Halysites and thus suggests the possible presence of the Niagara in the Hills.

155. BLAKE, WILLIAM P. Gold in Granite and Plutonic Rocks.

Am. Inst. Min. Eng., Trans., vol XXVI, pp. 290-298.

Mentions the occurrence of gold in ancient crystalline gneiss or granitic schists of pre-Cambrian age in the mines of the Homestake group of the Black Hills.

156. DARTON, NELSON H. Notes on the Geology of the Black Hills of Dakota.

Science, New ser., vol. III, pp. 418-419. Abstract of a paper presented before the Geological Society of Washington.

Describes a detailed section made from the base of the Cambrian to the White River Miocene along a line passing through Rapid City.

157. ——— Preliminary Report on Artesian Waters of a Portion of the Dakotas.

U. S. Geol. Surv., 17th Ann. Rept., pt. II, pp. 609-694, pls. LXIX-CVII, figs 50-65.

Refers briefly to the Black Hills uplift and gives a vertical section from the Black Hills eastward across South Dakota, showing the altitude and relations of the water-bearing strata.

158. FARR, MARCUS S. Notes on the Osteology of White River Horses.

Am. Phil. Soc., Proc., vol. XXXV, pp. 147-175.

The genus Mesohippus mentioned as occurring in the horizons of White River beds as follows: in Titanotherium beds, *M. bairdi*; in Oreodon beds, *M. bairdi*, *M. copei*; in Protoceros beds, *M. bairdi*, *M. copei*, *M. intermedius*. States that the Oreodon beds have furnished most of the best material. The three species are described in considerable detail, and various figures and a diagram are given showing the phylogeny of the horse series as now understood. A bibliography is given, also one plate showing a restoration of *Mesohippus bairdi*.

159. GANNETT, HENRY. Magnetic Declination in the United States.

U. S. Geol. Surv., 17th Ann. Rept., vol. I, pp. 211-440.

Gives on pp. 413-414 the declination of the magnetic needle in the various Black Hills counties.

- 160 HATCHER, J. B. Recent and Fossil Tapirs.

Am. Jour. Sci., 4th ser., vol. I, pp. 161-180, pls. II-V.

Describes a new species of *Protapirus*, *P. vavidus*, from the

Protoceras beds of the White River Miocene (Oligocene). Specimens were found four miles south of White River and five miles below the mouth of Porcupine creek, about one mile from the spot where the type of *Protoceras celer* was secured by Mr. H. F. Wells of Sturgis, who was the first to distinguish the *Protoceras* beds, and by whom they were shown to Dr. J. L. Wortman, who was the first to name and describe them. The author adds to our knowledge of the osteology of the genus *Protapirus*, especially to the skull and forelimbs; gives additional characters diagnostic of the various species *Protapirus* and *Colodon*; points out distinctive osteological and dental characters in the skulls of the five generally accepted species of recent tapirs; and reviews previous work of others on the phylogeny of the *Tapiridae* and *Helaletidae*. The specimens from the White River beds are: *Protapirus validus*, *P. simplex*, *Colodon (Lophiodon) occidentalis* and *C. dakotensis*.

161. MARSH, OTHNIEL C. The Dinosaurs of North America.

U. S. Geol. Surv., 16th Ann. Rept., pp. 143-414, pls II-LXXXV, figs. 1-66.

Describes the caudal vertebrae of *Barosaurus lentus* found near Piedmont, and shows the side, front and bottom views of one of the vertebrae. States that this is the most northern limit now known of the *Atlantosaurus* beds.

162. OSBORN, HENRY F. The Cranial Evolution of *Titanotherium*.

Am. Mus. Nat. Hist., Bull., vol. VIII, pp. 157-197, pls. III-IV, figs. 1-13, diag. I-II.

Studies the evolution of the cranium with the view of distinguishing the influences of sex, of age or growth and of individual variation from the truly retrogressive and progressive characters. Reviews the study of the *Titanotheridae* by others, much of which has to do with White River specimens, gives the principles of cranial and dental evolution, revises and defines the species and indicates their vertical distribution. Concludes that the characters upon which the genera *Symborodon*, *Diconodon*, *Brontops*, *Titanops*, *Allops*, *Haplacodon*, and *Diplocomus* are founded are either marks of sex, age, or individual variability and that these names should not be used.

163. PARKER, EDWARD W. Coal.

U. S. Geol. Surv., 17th Ann. Rept., part III, Min. Res., pp. 285-542.

States on page 515 that South Dakota appears for the first time in 1895 as a coal producer, 200 tons of lignite being mined near Edgemont.

164. RUSSELL, ISRAEL C. Igneous Intrusions in the Neighborhood of the Black Hills of Dakota.

Jour. Geol., vol. IV, pp. 23-43.

Contrasts these intrusions with those of the Henry mountains described by Mr. Gilbert, and those of New Mexico described by Col.

Dutton. Gives three plates of two figures each and describes the following: Little Sundance dome, Sundance hill, Mato Tepee or Devils Tower, the Little Missouri Buttes, Inyan Kara, Bear Butte, Crow Peak, Terry and Custer Peaks and Warren Peak. States that all have a common history. Refers to them as plutonic plugs and indicates that each owes its existence to the injection from beneath of a column of molten rock into stratified beds and the subsequent removal of the enclosing sedimentary strata so as to expose, with one exception the inner core of plutonic rock. Notes the absence of dikes and faults in immediate connection with plutonic plugs. Points out the similarity between the domes of sedimentary beds raised above the plugs and the far greater dome from which the Black Hills have been sculptured.

165. ——— On the Nature of Igneous Intrusions.

Jour. Geol., vol. IV, pp. 177-194.

Describes the several forms of igneous intrusions and discusses their origin. Cites the Black Hills region for various examples.

166. SMITH, FRANK C. The Occurrence and Behavior of Tellurium in Gold Ores. More Particularly with Reference to the Potsdam Ores of the Black Hills, South Dakota.

Am. Inst. Min. Eng., Trans., vol. XXV, pp. 485-515, figs. I-II. Discussion in same volume, pp. 1103-1108.

States that the discovery of tellurium in the Potsdam ores of the Black Hills was first made in specimens from the Welcome mine. Eleven photomicrographs of ores are given. Much of the paper is taken up with discussions of metallurgical processes.

167. VAN HISE, CHARLES R. Principles of North American Pre-Cambrian Geology.

U. S. Geol. Surv., 16th Ann. Rept., pp. 581-843, pls. CVIII-CXVI, figs. 101-162.

Discusses the nature of dikes and veins in the granite district of the Black Hills. States that the Black Hills afford one of the best instances known of the metamorphic effect of great intrusive masses of granite and that the production of peripheral cleavage parallel to an intrusive magma, and therefore normal to the pressure, is as fluely illustrated here as anywhere in America.

168. WIELAND, GEORGE R. Archelon ischyros; A New Gigantic Cryptodire Testudinate from the Fort Pierre Cretaceous of South Dakota.

Am. Jour. Sci., 4th ser., vol. II, pp. 399-412, pl. VI.

Gives description and relationship of a specimen that was found in the uppermost Fort Pierre, southeast of the Black Hills, near the South Fork of the Cheyenne.

1897.

169. BECKER, GEORGE F. The Witwatersrand Banket, With Notes on Other Gold-Bearing Pudding Stones. U. S. Geol. Surv., 18th Ann. Rept., part V, Min. Res., pp. 153-184. Refers briefly on p. 180 to the Black Hills gold-bearing conglomerate and notes its similarity to the Witwatersrand banket.

170. DAHL, WILLIAM H. A Table of the North American Tertiary Horizons, Correlated with One Another and With Those of Western Europe, With Annotations. U. S. Geol. Surv., 18th Ann. Rept., pt. II, pp. 327-348. The positions of the various White River beds are given, with notes on the same.

171. DAY, DAVID T. Mineral Resources of the United States, 1896.

U. S. Geol. Surv., 18th Ann. Rept., part V. Min. Res.

Refers on pp. 1851-1853 to the occurrence and production of fullers earth in the Black Hills. Two analyses and two columnar sections are given.

172. EMMONS, SAMUEL F. The Geology of Governmentment Explorations. (Presidential Address Delivered Dec. 16, 1896).

Geol. Soc. Wash., 8vo, pp. 3-39.

Science, n. s., vol. V, pp. 1-15, 42-51.

Mentions some of the more important expeditions to the Black Hills region and includes in the accompanying bibliography a list of the resulting publications.

173. FRAZER, PERSIFOR. Notes on the Northern Black Hills of South Dakota.

Am. Inst. Min. Eng., Trans., vol. XXVII, pp. 204-231, pls. I-III.

Discusses the general economic geology of the Northern Black Hills, with especial reference to the Galena District. A short list of papers on the economic and structural geology of the region is given.

174. HATCHER, J. B. Diceratherium Proavitum.

Am. Geol., vol. XX, pp. 813-816.

Corrects some typographical errors in the article referring to this fossil in the Am. Geol., vol. XIII, pp. 360-361, 1894. and gives reasons for placing the form in the genus Diceratherium rather than aceratherium.

175. MARSH, OTHNIEL C. Principal Characters of the Protoceridae, Part I.

Am. Jour. Sci., 4th ser., vol. IV, pp. 165-176, pls. II-VII, figs. 1-7.

Describes and figures male and female skulls of Protoceras, also describes and figures the skull and dentition of Calops.

176. ORTMAN, ARNOLD E. New Species of the Palinurid Genus *Linuparus* found in the Upper Cretaceous of Dakota.

Am. Jour. Sci., 4th ser., vol. IV, pp. 290-297.

Describes and figures two specimens collected by Mr. Wells from the Niobrara group at the head of Cottonwood creek, Meade county. These represent the first remains of this group of Decapoda found on the American continent and surpasses in completeness of preservation anything that is known of this group in the European deposits.

177. RIES, HEINRICH, The Fullers Earth of South Dakota.

Am. Inst. Min. Eng., Trans., vol. XXVII, pp. 833-835.

Describes the fullers earth from near Fairburn, Argyle, Minnehaha and other localities and discusses its probable economic value. Six analyses are given.

178. SCOTT, SAMUEL. Map of the Black Hills of South Dakota and Wyoming with Full Descriptions of Mineral Resources, etc.

Sm. 8vo, 40 pp., map, 1897, Custer City, S. D.

Gives brief descriptions of the formations, rocks and minerals of the Black Hills and notes the place of occurrence of many of the minerals. A colored map, scale of five miles to the inch, shows the areal distribution of the formations.

179. SMITH, FRANK C. The Potsdam Gold Ores of the Black Hills of South Dakota.

Am. Inst. Min. Eng., Trans., vol. XXVII, pp. 404-428, map.

Discusses the general and economic geology of the Northern Connected district, with short reference to the Galena district.

180. STANTON, TIMOTHY W. A Comparative Study of the Lower Cretaceous Formations and Faunas of the United States.

Jour. Geol., vol. V, pp. 579-624.

Refers in a general way to the Black Hills region and particularly

to the Black Hills *Atlantosaurus* beds. Gives a bibliography, a number of the papers of which refer to the Black Hills region.

181. DAY, WILLIAM C. Stone.

U. S. Geol. Surv., 19th Ann. Rept., part VI, continued, Min. Res., pp. 205-309.

Gives on p. 278 the crushing strength of six kinds of sandstone quarried at Rapid City.

1898.

182. DILLER, JOSEPH S. The Educational Series of Rock Specimens, Collected and Distributed by the United States Geological Survey.

U. S. Geol. Surv., Bull. No. 150, 400 pp.

The following Black Hills Rocks are described: Phonolite, described by Mr. Whitman Cross, and Mica-Schist (Tourmaline-Biotite-Schist), described by Mr. W. S. Bayley.

183. FARRINGTON, O. C. [Report to the Director].

Field Columb. Mus., Ann. Rept. of the Director, Report Series, vol. I, No. 4, pp. 263-343.

Gives on pages 277-278 a brief account of the work of the party sent by the museum in 1898 under the author's direction to the White River bad lands, where seven weeks were spent in making collections of fossils.

184. MARSH, OTHNIEL C. Cycad Horizons in the Rocky Mountain Region.

Am Jour. Sci., vol. VI, p. 197.

Gives a short review of our knowledge of the cycad horizons of the West, with particular reference to the Black Hills localities.

185. ——— Jurassic Formation on the Atlantic Coast—Supplement.

Am. Jour. Sci., 4th ser., vol. VI, pp. 105-115.

Under the head of "Cycad Horizons" the author makes brief mention of the numerous and well-preserved cycads of the Black Hills.

186. OSBORNE, HENRY F. The Extinct Rhinoceroses.

Am. Mus. Nat. Hist., Mem., vol. I, pt. III, pp. 75-164, pls. XIIIa-XX, 49 figs.

Part of a memoir which endeavors to establish a sound philosophical basis for the morphology of the rhinoceroses, derived from their primitive, parallel and divergent characters, and leading toward the discovery of their origin, phylogeny and distribution. This part of the

memoir is based mostly on a study of the skull and teeth. Makes frequent reference to specimens from the White River basin, some of which are figured.

187. TODD, JAMES E. First Biennial Report of the State Geologist.

South Dakota Geol. Surv., Bull. No. 2, pp. 1-13. Dated October 29, 1894.

Contains information in regard to the author's field work in the Black Hills region during the year 1894.

188. ——— Second Biennial Report of the State Geologist.

South Dakota Geol. Surv., Bull. No. 2, pp. 15-24. Dated October 31, 1896.

Contains information in regard to the author's field work in the Black Hills region during the year 1895.

189. ——— Section Along Rapid Creek from Rapid City Westward.

South Dakota Geol. Surv., Bull. No. 2, pp. 27-40, pls. II IV.

Gives the purpose and history of the work and the reasons for choice of location. Describes the geological formation along the section, indicates three or four terraces and gives economic notes on certain resources. Notes the finding of fossils in the Purple limestone and describes the complex folding in the Algonkian slates.

190. ——— A Reconnaissance Into Northwestern South Dakota.

South Dakota Geol. Surv., Bull. No. 2, pp. 43-68, pls. V-X.

Describes the topography, altitude, drainage, and geologic features of the area and gives a number of columnar sections. Notes the presence of White River and Loup Fork Miocene beds overlying the Laramie in Harding, Butte and Ewing counties, an area of considerable disturbance in Harding county and lignite beds of importance in Ewing, Hardin and Martin counties. Economic notes on the various resources are given.

191. ——— The Geology Along the Burlington and Missouri Railway.

South Dakota Geol. Surv., Bull. No. 2, pp. 69-82.

Describes the geological features of the Hills along the railway, beginning with Ardmore, near the southern limit of the state and continuing northward to Deadwood and to Spearfish.

192. ——— Elevations In and About the Black Hills.

South Dakota Geol. Surv., Bull. No. 2, pp. 83-87.

Gives heights of 164 localities in the Black Hills region, the

authorities for which are the Oelrich, Hermosa, Rapid, Deadwood and Custer topographic sheets published by the United States Geological Survey and the railroad profiles of the Burlington and Missouri Valley railway.

193. ——— Additional Notes on the Limits of the Main Artesian Basin.

South Dakota Geol. Surv., Bull. No. 2, pp. 88-115.

Reference is made to the relation of the Black Hills region to the main artesian basin.

194. ——— The Exploration of the White River Bad Lands in 1896.

South Dakota Geol., Surv., Bull. No. 2, pp. 117-135, pls. XII-XV.

Briefly describes the topography and designates five base levels of erosion. Gives notes on the various formations, discusses the life of the Miocene and the geological history of the Tertiary and post-Tertiary age. Refers to the volcanic ash stratum found in Cedar and Sheep mountains and treats of the economic resources of the region.

195. WALCOTT, CHARLES D. Report of the Director.

U. S. Geol. Surv., 19th Ann. Rept., pt. I, 422 pp.

Gives on p. 56 a short account of field work by the Director in the Black Hills in August, 1897. Refers on p. 94 to triangulation work in the Black Hills forest reserve, including the location of a meridian line at Deadwood. The elevations and exact locations of all bench marks determined on the Deadwood, Hermosa, Rapid and Harney Peak quadrangles are given on pages 281-314.

196. WARD, LESTER, F. Descriptions of the Species of Cycadeoidea, or Fossil Cycadean Trunks, thus far Determined from the Lower Cretaceous Rim of the Black Hills.

Gives a description of twenty-one species, twenty of which are new to science. The paper is the result of a careful study of a collection of one hundred and fifty-five Black Hills specimens belonging to the following named institutions: twenty-five to the United States National Museum, two to the State School of Mines, two to the Woman's College of Baltimore and one hundred and twenty-six to Yale University.

197. WIELAND, GEORGE R. The Protostegan Plastron.

Am. Jour. Sci., 4th ser., vol. V, pp. 15-20, pl. II.

Describes and figures two specimens from the uppermost Fort Pierre Cretaceous near the Cheyenne river. The type name *Archelon ischyros* is abandoned and *Protostega ischyra* used instead.

1899.

198. CASE, E. C. The Development and Geological Relations of the Vertebrates. V. Mammalia, Continued.
Jour. Geol. vol. VII, pp. 163-187,
Refers frequently to fossils from the White River bad lands.
199. DARTON, NELSON H. Bad Lands of South Dakota.
Nat. Geog. Mag., vol. X, pp. 339-343, 4 plates.
Gives a short description of the White River bad lands and directs how the region may be most conveniently reached.
200. ——— Jurassic Formations of the Black Hills of South Dakota.
Geol. Soc. Am., Bull., vol. 10, pp. 393-396, pls. 42-44.
The author reviews previous investigations of the Jurassic rocks of the Black Hills, indicates the uncertainty of the Jurassic-Cretaceous contact, gives a table showing the classification, composition and nomenclature of the Jurassic and adjoining formations, also several columnar sections and a list of fossils thus far reported and outlines the history of the Black Hills Jurassic deposits.
201. DAY, DAVID T. Gold and Silver.
U. S. Geol. Surv., 20th Ann. Rept., vol. 6, Min. Res., pp. 103-111.
Gives the production of gold and silver in the Black Hills for 1896, 1897, 1898.
202. EASTMAN, C. R. Jurassic Fishes from Black Hills of South Dakota.
Geol. Soc. Am., Bull., vol. 10, pp. 397-408, pls. 45-48.
Describes and figures specimens of *Pholidophorus americanus*, *Amiopsis? dartoni* and an undetermined ganoid, all of which were collected in 1893 by Mr. N. H. Darton from the basal Jurassic near Hot Springs.
203. FARRINGTON, OLIVER C. A Fossil Egg from South Dakota.
Field Columb. Mus., geol. ser., vol. I, pp. 193-200, pls. XX-XXI.
Describes a supposed petrified egg of an anatine bird of early Miocene age, found by Mr. Kelly Robinson, of Dakota City.
204. GANNETT, HENRY. The Forests of the United States
U. S. Geol. Surv., 19th Ann. Rept., pt. V, pp. 1-66, pls. V-XIII.
Gives statistics of the Black Hills lumber supply and on pp. 49-52 briefly describes the Black Hills reserve.
205. GRAVES, HENRY S. Black Hills Forest Reserve.
U. S. Geol. Surv., 19th Ann. Rept., pp. 67-164, pls. XIX-XXXVI, map.
Gives the limits of the reserve and describes the topography of the region. Indicates the lands suitable for agricultural, grazing

and mining purposes, and the character, distribution, condition and yield of the forest covered areas. Gives sources of injury to the forests, discusses the reproduction, growth and yield of the yellow pine, suggests method of management and gives a detailed description of the forest as developed along the various streams of the Hills. A map accompanying the paper shows the land classification and density of standing timber in the Rapid, Deadwood, Sundance, Hermosa and Harney Peak quadrangles.

206. HOLMES, J. A. Mica Deposits in the United States.

U. S. Geol. Surv., 20th Ann. Rept., vol. 6, continued, Min. Res., pp. 691-707.

Makes frequent reference to the mica of the Black Hills, giving a brief account of its mode of occurrence, nature of the deposits, quantity, distribution, quality and value of the mica, structure, origin, and minerals of the mica dikes and methods of prospecting and mining. Gives the present condition of the mica industry in the Hills and indicates its probable future development.

207. IRVING, JOHN D. A Contribution to the Geology of the Northern Black Hills.

Contributions from the Geological Department of Columbia University, vol. IX, No. 65. [Annals N. Y. Acad. Sci., vol. XII, No. 9, pp. 187-340, pls. V-XVI, figs. 5-20.]

Gives a detailed account of the geology of a portion of Lawrence county, the area chiefly concerned being about eight miles square and situated in the northwestern part of the Deadwood quadrangle. The paper includes a discussion of the topography, stratigraphy, eruptive rocks and ore bodies of the region. The eruptive rocks are described as: Intrusions in the Algonkian, intrusions in the Cambro-Silurian, and intrusions in the Carboniferous. Of these the first shows only dikes, they being of two distinct varieties: pre-Cambrian dikes of amphibolite and hornblende schist and dikes of phonolite, quartz-porphry, etc., of early Tertiary time. The second shows laccolites, sheets and dikes. The third includes thick, irregular masses, not properly classed as dikes, sheets, or laccolites, but apparently belonging to none or to all three of these types. The views of previous writers on the eruptive rocks of the Hills are given with reference to the causes influencing the formation of the various kinds of intrusions. The author considers that the influences of the rocks into which the magmas are intruded are the most important, and in the Northern Black Hills this has been the case almost without exception. A detailed description of the petrography and areal distribution of the eruptive rocks is given, the following rocks being determined: Quartz-aegirite-porphry, mica-diorite-porphry, dacite, tonalite and augite-vogesite of the post Cretaceous age and various amphibolites of pre-Cambrian age. The

author also describes the ores of the area, attention being given chiefly to the siliceous ores of the Cambro-Silurian and the Carboniferous formations and discusses the probable method of their formation. A map showing the areal distribution of the formations accompanies the paper.

208. MARSH, OTHNIEL C. Footprints of Jurassic Dinosaurs,

Am Jour. Sci., 4th ser., No. 39, pp. 227-233, pl. V.

Describes and figures the first footprints found in Jurassic strata in this country. They are all tridactyl and were found by Mr. Wells in 1898 in the *Atlantosaurus* beds on the southwestern border of the Black Hills. The author also discusses the various post-Paleozoic strata of the Hills region and gives a table including the characteristic fossils of the various horizons.

209. MATTHEW, W. D. Is the White River Tertiary an Aeolian Formation?

Am. Nat., vol. XXXIII, pp. 403-408.

States objections to the Lacustrine hypothesis with especial reference to the stratigraphy and the fauna. Advances the theory that the deposits are chiefly aeolian, similar in origin to the prairie loess but that the sandstones are perhaps mostly fluvialite.

210. O'HARRA, CLEOPIAS C. and FORSYTH, A. Notes on the Geology and Mineral Deposits of a Portion of the Southern Black Hills.

South Dakota School of Mines, Bull., 41 pp., 11 figs.

Discusses the general geology, mineralogy and mining interests of an area southeast of Harney Peak, near the eastern limit of the granite district.

211. PARKER, EDWARD W. Gypsum.

U. S. Geol. Surv., 20th Ann. Rept., vol. 6, continued, Min. Res., pp. 657-666

Gives statistics of the gypsum of the United States and other parts of the world and on page 661 gives the total production and value of gypsum in South Dakota [Black Hills] during the past ten years.

212. TALLENT, ANNIE D. The Black Hills; or the Last Hunting Ground of the Dakotahs.

8vo. XXII and 713 pp., St. Louis, 1899.

An interesting popular history of the Black Hills since 1874. Written by the first woman to enter the Black Hills for the purpose of settlement. Contains many general references to the geology and geography of the region.

213. WARD, LESTER F. The Cretaceous Formation of the Black Hills as Indicated by the Fossil Plants, with the Collaboration of Walter P. Jenney, William M. Fontaine and F. H. Knowlton.

U. S. Geol. Surv., 19th Ann. Rept., pt. II, pp. 521-946, pls. 57-172.

An exhaustive report on the Cretaceous rim of the Black Hills, particularly the Lower Cretaceous, as interpreted by the plants discovered, the most important of which are cycads. Gives a historical review of our knowledge of the Cretaceous of the Black Hills, indicate the Lower Cretaceous age of a considerable series of strata below the Dakota sandstone, describes the Cretaceous flora, particular attention being given to the cycads, and gives in detail the geology of the Minnekahta, the Black Hawk and the Hay Creek regions. Numerous sections are given, including a general section of the Hay Creek coal field and a general section of the strata occurring in the Black Hills, the latter section showing the position, age, divisions, origin and mode of occurrence and the lithologic and water-bearing character of the various strata. Professor Jenney contributes the field observations in the Hay Creek coal field, and Professor Fontaine the notes on the Lower Cretaceous plants from the same field. Dr. Knowlton describes the fossil wood. A table gives the foreign, the American and the Black Hills distribution of eighty-six species of cretaceous plants, most of which are figured.

214. WIELAND, GEORGE R. A Study of Some American Fossil Cycads, Part I, the Male Flower of Cycadeoidea.

Am Jour. Sci., 4th ser., March, pp. 219-226, pls. II-IV.

Describes the male flower of *Cycadeoidea ingens* from the Black Hills and gives reference to the Black Hills literature.

215. ——— A Study of Some American Fossil Cycads, Part II. The Leaf Structure of Cycadeoidea.

Am. Jour. Sci., 4th ser., No. 40, pp. 305-308, pl. VII.

Discussion based largely on specimens from the Black Hills.

216. ——— A Study of Some American Fossil Cycads, Part III. The Female Fructification of Cycadeoidea.

Am. Jour. Sci., 4th ser., No. 41, pp. 383-391, pls. VIII-X

Compares American and European Cycads and describes particularly the fructification of certain Black Hills cycads.

217. ——— Cycadean Monoecism.

Am. Jour. Sci., 4th ser., No. 44, p. 164.

Discusses various examples of monoecism as shown in specimens from the Black Hills.

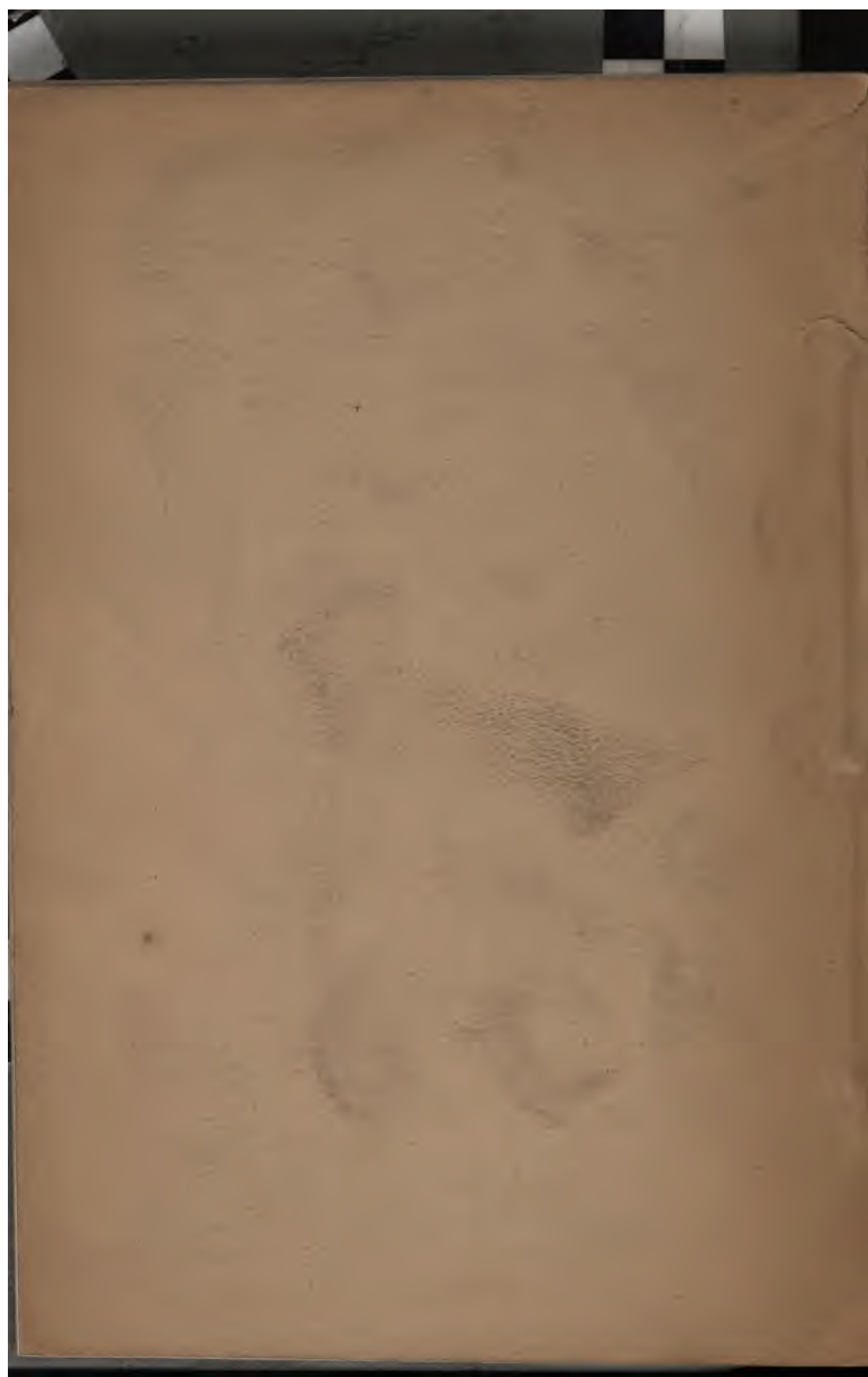
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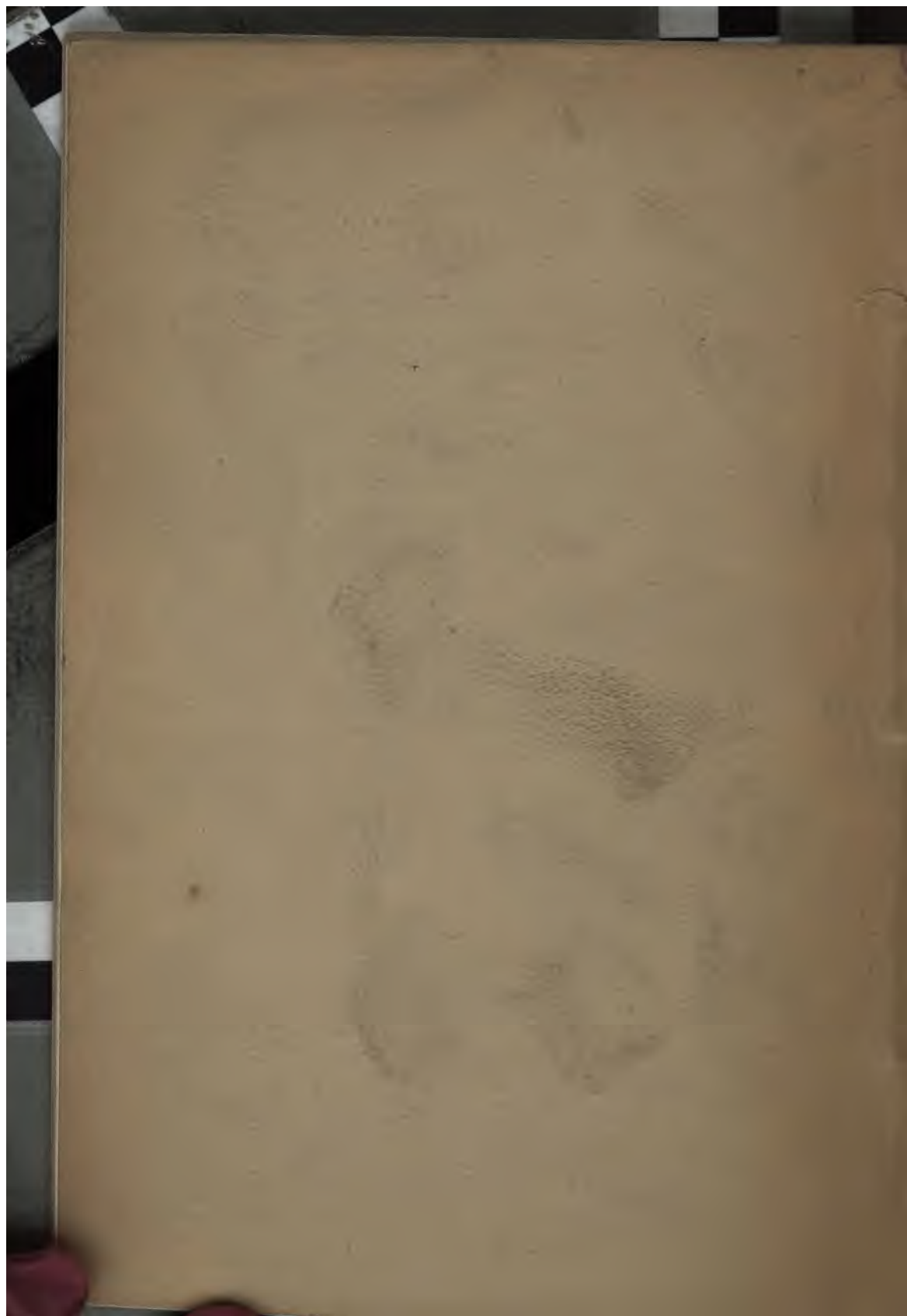
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THE CYANIDE PROCESS

IN THE

MINES OF MICHIGAN

MAY 23 1906

BLACK HILLS OF SOUTH DAKOTA.

By CHARLES H. FULTON, M. E.

BULLETIN NO. 5,

OF THE

SOUTH DAKOTA SCHOOL OF MINES

DEPARTMENT OF METALLURGY.

RAPID CITY, SOUTH DAKOTA,

FEBRUARY, 1902.



BULLETIN NO. 5.

OF THE

SOUTH DAKOTA SCHOOL OF MINES

DEPARTMENT OF METALLURGY.

The Cyanide Process in the Black Hills of South Dakota.

BY CHARLES H. FULTON, M. E.

RAPID CITY, SOUTH DAKOTA.
FEBRUARY, 1902.



Letter of Transmittal.

SOUTH DAKOTA SCHOOL OF MINES, }
RAPID CITY, February 1st, 1902. }

SIR:--I have the honor to transmit herewith a paper by
Charles H. Fulton, E. M., on "The Cyanide Process in the Black
Hills of South Dakota."

I submit it with the recommendation that it be published as
Bulletin No. 5 of the School of Mines.

Respectfully,

ROBERT L. SLAGLE, President.

Hon. Frederick A. Spafford,
President Regents of Education.

Introduction.

The cyanide process has become such an important factor in the gold production of the Black Hills in the last few years that a paper treating of the process as applied in this section seems to be timely.

The object of this paper is to give a comprehensive and detailed view of the cyanide process as applied in the Black Hills. It describes the practice at most of the important mills in the district, more attention being paid to the methods used, than to the details of mill construction and mill appliances. Wherever possible costs of milling have been ascertained and stated with as much detail as possible, it being readily understood that information of this nature is not always readily obtainable. While the Black Hills do not claim anything new in cyanide developments, the claim can be made that in no district in the United States does a greater diversity of practice exist, and with good reason. The district has mills treating tailings from stamp amalgamation, mills whose practice approximates certain New Zealand practice, of crushing with cyanide solution in stamp batteries, and treating separately the resulting sands and slimes, and also mills of the more general type, dry crushing the ores and cyaniding in the usual way, by percolation. The reason for this diversity of practice is the difference in the nature of the ores, which, while of the same general character in the main, differ widely as regards the condition in which the gold is found, necessitating more than one method of treatment.

The writer wishes to express his thanks to all those who have so kindly and freely aided him in his search for information, his especial thanks being due to the following gentlemen: Mr. D. C. Boley, Mr. W. D. Parker, Mr. James Hartgering, Mr. John Hinton, Mr. W. L. McLaughlin, Mr. R. B. Hughes, Mr. B. Cook, Mr. J. K. Vanatta, Mr. F. Mella, Mr. Hildner, Mr. N. W. Chapman, Mr. R. F. Flintermann, Mr. Griggs, Mr. Wm. Letson, Messrs. Allen Bros. & Soule, Mr. John Randall, Mr. Empson, Mr. F. Steele, Mr. W. B. Millerkin and Mr. W. S. Elder.

PART I.

Description of the Mills and the Methods Used.

The Golden Gate Cyanide Plant.

This is the oldest cyanide mill in the district, and is known as the Rossiter, the First Ward or the Deadwood Cyanide Mill. The mill was erected in 1892 as a cyanide mill, but was never in continuous operation, although a great deal of ore has been treated there. Since its construction no radical changes have been made in the mill, except to increase its capacity, and in consequence it represents the past type of mill. It is a dry crushing mill, having facilities for drying and roasting the ore. Roasting, however, as far as the writer's information goes, has not been used of late. The practice described in the following pages was that in vogue during Mr. D. C. Boley's administration.

NATURE OF THE ORE TREATED.—The ore comes from the Bald Mountain district and is in part oxydized and in part non-oxydized. This latter is commonly known as "blue ore." Both kinds are highly siliceous, the unoxydized being a hard blue siliceous ore, very dense, carrying a small percentage, 2 to 6 per cent, of finely disseminated pyrites. The oxydized ore is more or less porous and of a somewhat shaly nature. The blue ore is much more difficult to cyanide than the oxydized ore, and as both come from the same mine, mixtures of the two are not always avoidable. The two classes of ore are best treated separately, in order to get the best results. The extraction on blue ore is low. The ore ranges in value from \$10 to \$30 per ton, the average being \$12 to \$15.

THE CRUSHING OF THE ORE.—The situation of the mill site is not very favorable as regards slope, and hence the crushing department has of necessity a considerable number of elevators, as shown in the scheme of crushing. As the mill is a dry crushing mill, provision is made to collect as much dust as possible. All the rolls, elevators and screens are connected by rectangular wooden flues, with a 55 inch Sturtevant fan. The dust collected by the fan is discharged into collecting bin No. 1 through a rectangular horizontal flue. In this first bin the coarser dust settles, while the finer material is blown out through another rectangular horizontal flue into the bin No. 2, where more material settles.

The finer dust which escapes from bin No. 2 passes through a long wooden flue (100 feet long, situated on the roof of the main mill building) into a large dust chamber provided with an exhaust stack. The dust collected amounts to 1-15 to 1-12, or 7 to 9 per cent of the amount of ore crushed. The material thus collected contains nothing coarser than what will pass through a 120 mesh sieve. A diagrammatic sketch of the dust catching apparatus is shown. Bins No. 1 and 2 are cylindrical, 8 feet in diameter and made of boiler iron.

THE CRUSHING AND SCREENING MACHINERY.—Grizzley is short, 3 feet long, and spaces between bars are $1\frac{1}{4}$ inch.

The rough crushing is done in a Gates No. 2 gyratory crusher, crushing to a $1\frac{1}{2}$ inch ring. The capacity of this crusher is 65 tons per 24 hours when running on dry ores, and but about 30 tons when running on wet ore. The other crushing machinery of the mill has a capacity of about 100 tons per 24 hours, but the mill is limited to 65 tons by its tankage and rough crusher.

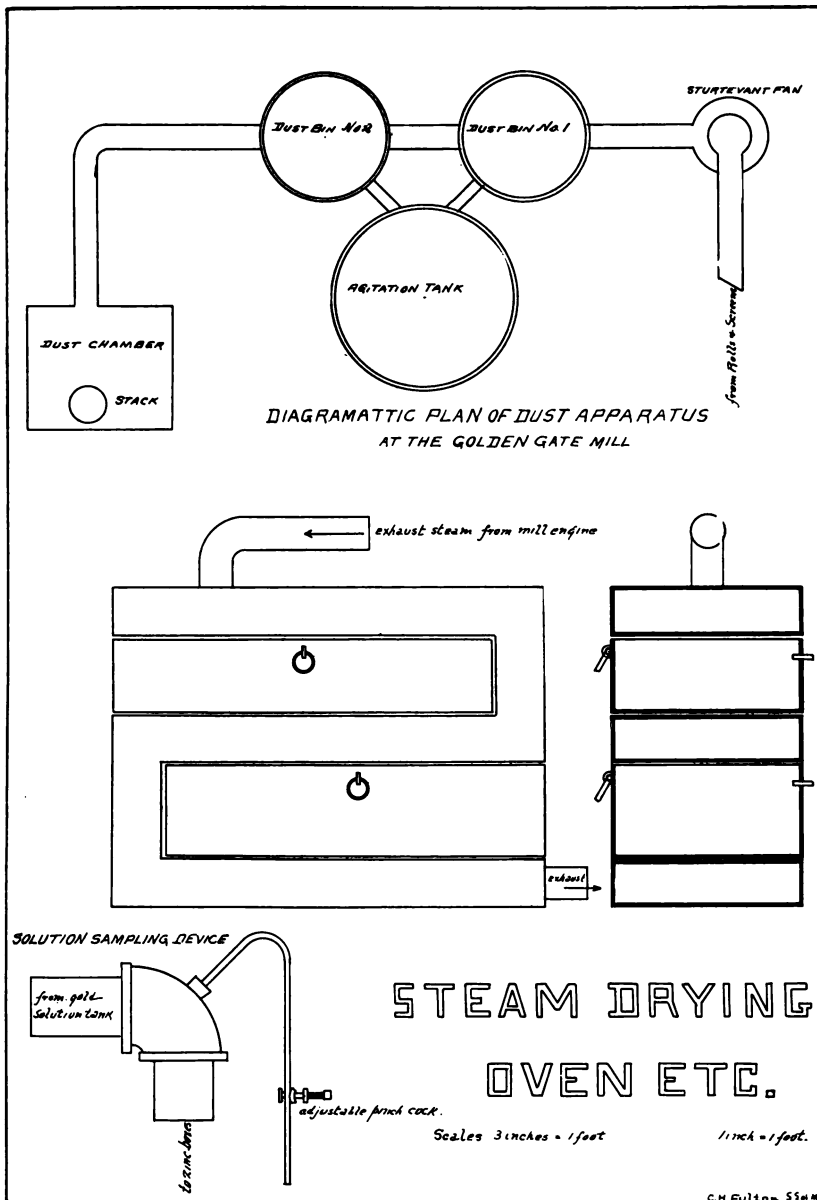
Rolls.—There are five sets of rolls in the mill. One pair of Gates rolls for coarse crushing and one pair of Gates and one pair of Bowers rolls for the medium crushing. The Gates rolls are at present crushing all the ore, the Bowers being out of use. There are two pair of Gates rolls for fine crushing.

The coarse crushing rolls are 26 inches in diameter and 16 inch face; rolled steel shells 4 inches thick are used, and the last set wore for 12 months. The speed of these rolls is 90 revolutions per minute.

The rolls for medium crushing are 26 inches in diameter and 12 inch face. The speed of the rolls is 120 revolutions per minute.

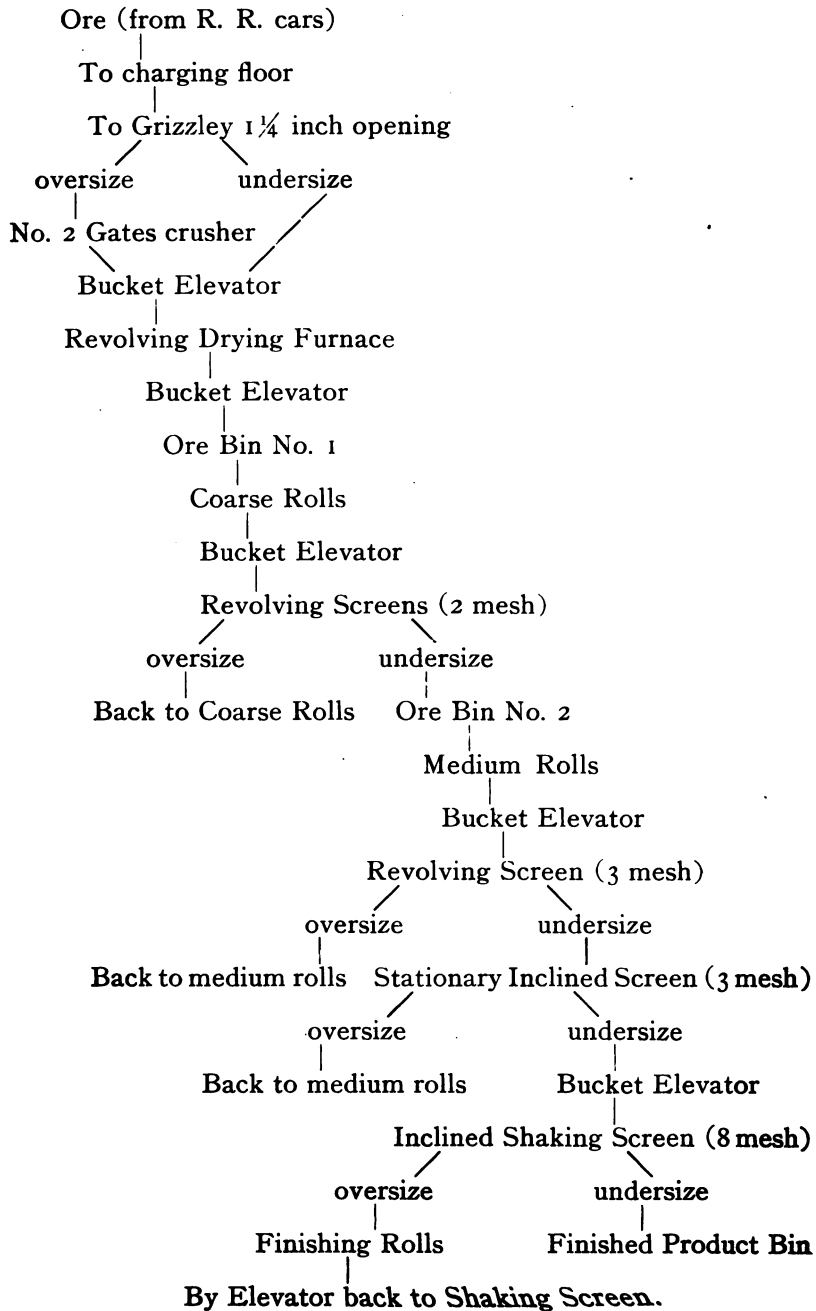
The rolls for fine crushing have the same size and speed as the medium crushing rolls.

The size of the Bowers rolls, which are not in use, is, diameter 26 inches and face 14 inches.





The following diagram is illustrative of the crushing:



The Revolving Screens (of which there are 2) screen the ore as it comes from the coarse rolls, and are 7 feet long and 3 feet in diameter. The screening surface is 2 mesh wire cloth, 4 openings per square inch.

The revolving screens which take the material from the medium rolls are also 7 feet long and 3 feet in diameter. The screening surface is 3 mesh wire cloth, 9 openings per square inch.

The 2 screens which take the material from the fine rolls are shaking screens. These are built double, each single screen having an area of 16 square feet, making 64 square feet for the two double screens. These screens are inclined at 45° and make 168 vibrations per minute. The power is transmitted to the screens by chain and sprocket. The screening surface is 8 mesh, No. 16 wire, 64 openings per square inch. As these are the finishing screens, they determine the size of the ore cyanided. It has already been stated that the dust apparatus takes out everything above 120 mesh, so that the material cyanided ranges between 8 and 120 mesh. There is probably only a small portion, however, as coarse as 8 mesh, for the reason that the finishing screen being an inclined flat screen, most of the material as coarse as this is carried back to the fine rolls for recrushing.

There is also a stationary inclined screen (3 mesh) placed in connection with the revolving screens of the medium crushing rolls, as may be seen by referring to the scheme of crushing. Its utility is doubtful. It could be done away with by having a finer mesh in the revolving screens. It will also be noticed that the material from the medium rolls undergoes a triple screening; *1st*, by revolving screen, *2nd*, by stationary inclined screen, and, *3rd*, by the inclined shaking screens. This relieves the finishing or fine rolls very much.

THE DRYER.—This is a long cylindrical furnace of the White-Howell type, 30 feet long and 5 feet in diameter, which with ore carrying considerable moisture has a capacity of 100 tons per 24 hours. With an ordinary percentage of moisture it makes one revolution in 35 seconds and consumes $1\frac{1}{2}$ to 2 cords of wood (pine) for 60 to 65 tons of ore.

THE LEACHING DEPARTMENT OF THE MILL.—There are 6 leaching vats, 3 in a row, built of steel, 24 feet in diameter and 36 inches deep, holding 50 tons of dry ore. There are no bottom or side discharge gates, the tailings being shoveled out over the side into cars. The tanks have the usual slat bottom, the filter

consisting of a layer of cocoa matting, burlap, and another cocoa matting on top of this. The top matting protects the burlap, which is the real filter. The top cocoa matting lasts about $2\frac{1}{2}$ years without any renewal. The actual leaching depth of the vats is $32\frac{1}{2}$ inches, deducting from this about $1\frac{1}{2}$ inches, the ore not coming flush with the top, the depth of ore is 31 inches, evidently a very shallow vat. These vats have been in use for 6 years.

The 2 gold solution tanks are 10 feet in diameter and 6 feet deep and built of steel, placed just above the zinc boxes. The 2 sump tanks are the same size as the gold tanks, and situated below the floor, under the zinc boxes.

The strong and weak solution tanks, or distributing tanks, are also of steel, 10 feet in diameter and 8 feet deep, and placed at the head and above the leaching vats.

The solutions as they come from the leaching vats are very clear, and owing to the shallow depth of the vats the leaching is very rapid; in fact, so rapid that it must at times be checked by the valves, in order to maintain the proper rate of flow through the zinc boxes, and also keep the solution sufficiently long in contact with the ore pulp.

The pipes which carry the solution to the tanks are $2\frac{1}{2}$ inch pipes. The discharge pipes from the filters are 3 inch pipes. The piping is arranged in the usual way so that strong and weak solution can be run into the respective zinc boxes.

The mill is also provided with a vacuum filter arrangement, but that is not at present in use except to drain tanks of moisture, as the leaching, if anything, is too rapid. The air pump is used to furnish air for the treatment of the dust, as will be described under the heading of "Dust Treatment."

THE ZINC BOXES.—There are two zinc boxes, one for "strong" solution and one for weak solution. The boxes are $10\frac{1}{2}$ feet long, 30 inches wide and have a depth of zinc of 24 inches. The box is divided into 9 compartments, the last two of which do not contain any zinc, but serve to settle any fines before discharging into the sump tanks. The boxes are provided with inclined bottoms, and a side launder to facilitate the clean up.

The fine precipitates are washed into a round steel filter tank, 3 feet in diameter, provided with a heavy canvas filter and connected with the vacuum pump. All of the finer portion of the precipitates are thoroughly washed in this tank before being transferred to the acid tank.

THE CYANIDING OF THE ORES.—The vats are charged by end dump steel cars, holding about 1200 to 1500 pounds of crushed ore. The tracks run close to the side of each row of vats and at a level with their top. The cars are charged from the finished product bin by the usual chute. A change has recently been adopted in charging the cars, necessitated by the fact that it was found advisable to wet the ore with cyanide solution before charging into the vats. This is done by letting a carful of ore flow out on a platform in front of the chute, then moistening it with cyanide solution, shovelling it over, then transferring it to the cars and then into the vats. The amount of cyanide solution used is just enough to thoroughly moisten the ore. Its strength is $\frac{1}{4}$ per cent, or 5 pounds of Potassium Cyanide per ton of solution. The moistened ore is allowed to stand only a short time, till the car comes back for the next load, but repeated tests have shown that in that time about 40 per cent of the gold goes into solution. As the ore is dumped from the cars into the vats, it is raked down by men standing in the vats. When conditions are favorable it takes about 16 hours to charge a vat, two men and one car being employed in the work.

The strong solution is then turned on, the vats being filled from the top, and allowed to stand for about 24 hours, although this time is sometimes varied. The strength of this solution is 5 pounds of cyanide per ton. This solution is then circulated for some time and then replaced by a weak solution containing $2\frac{1}{2}$ pounds of cyanide per ton of solution. This is not allowed to stand, but is continuously circulated. The total amount of weak and strong solution that is used on the ore is from 50 to 60 tons, the relative amount of weak and strong solution differing with the class of ore. The average rate of leaching is about 3 tons of solution per hour. The weak solution is finally displaced by 8 to 10 tons of wash water per vat, the ore being dried as far as possible by the use of vacuum, to draw off as much moisture as possible. The amount of moisture in the tailings after the application of the vacuum pump is about 8 to 10 per cent. (?)

The time of leaching and washing is generally about 96 hours. Vats are usually discharged in 12 hours, the tailings being shoveled out over the side into cars. The total time required for one vat thus being 124 hours to 140 hours.

Slacked lime is used to neutralize the acidity of the ore, 8 pounds per ton being added. This is added in proper quantity

at suitable intervals to the finishing rolls, thus insuring a very fair mixture of ore and lime.

The aim is to have a "protective alkalinity" of about 2.2 pounds of lime per ton of solution. The protective alkalinity is that part of the alkalinity of the solution not due to the potassium cyanide or other cyanide salts. It is usually expressed in pounds of alkali per ton of solution. (See Part II, "Protective Alkalinity.")

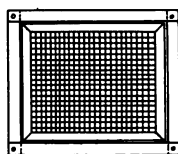
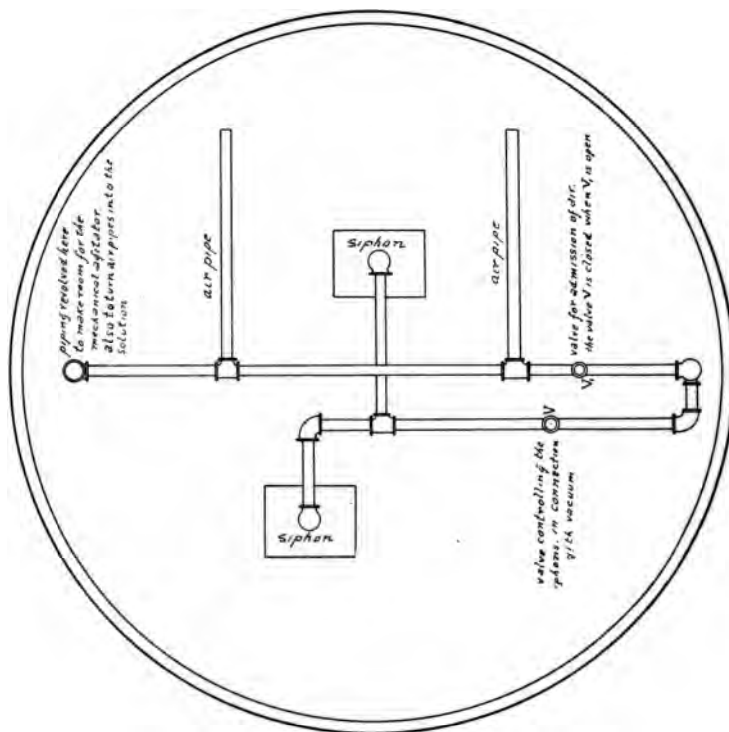
The consumption of cyanide is about $\frac{3}{4}$ pounds per ton of ore, and the actual extraction of values, or the saving, is about 79 to 80 per cent.

The rate of flow of the solution through the zinc boxes is 1 ton per hour for the strong solution and 3-5 tons per hour for the weak solution. The precipitation is very good, no trouble being met with in the zinc boxes, the solution issuing from the boxes rarely running more than 4 to 20 cents per ton of solution.

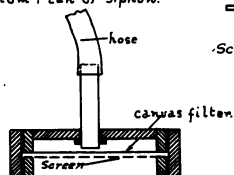
DUST TREATMENT.—The dust or fines from the crushing, which, as already stated, amount to from 7 to 9 per cent. of the material crushed, is treated separately by agitation in a tank provided with mechanical stirring apparatus. The agitation tank is of steel, 10 feet in diameter and 56 inches deep. The agitator is a central steel shaft $2\frac{1}{2}$ inches in diameter, provided at the bottom with two horizontal arms and driven at top by bevel gear. The agitator can be lifted out of the tank by means of pulley and chain. The usual speed of the agitator is 12 revolutions per minute.

In treating the dust the tank is first filled with 10 tons of strong solution, 5 pounds of cyanide per ton, and then 8 tons of dust are added by means of a movable 6 inch galvanized iron pipe provided with a conical hood at the end. This hood dips beneath the solution, preventing dust. The charging pipe leads from the dust bins, which are immediately above the agitator tank, and have already been mentioned. The agitator is set in motion at the beginning of the dust charging and the mass is agitated for six hours. Then air is pumped through for an hour, the air being furnished by the reversal of the vacuum pump. This first treatment with strong solution by agitation and aeration gives an extraction of about 50 per cent of the values. The treatment with strong solution is followed by four treatments with weak solution, containing from 1 to $2\frac{1}{2}$ pounds of cyanide per ton. The treatments with weak solution are identical with the treatment with strong solution, except time consumed, which is

agitation for $\frac{1}{2}$ hour and aireation for 1 hour. After the aireation the slimes are allowed to settle for 12 hours and the supernatant solution, amounting to about 60 per cent, is syphoned off, the syphon being a square wooden box provided with canvas filter and started by the vacuum. (See drawing for apparatus for syphoning and agitation.) The solution which is drawn off is passed again through a canvas filter, which is a long, inclined launder-like box, in which a horizontal sheet of heavy canvas is stretched, the solution entering beneath the canvas and being forced up through it. This effectually clears the solution of all suspended matter and leaves it in condition to enter the zinc boxes. By these successive treatments an actual extraction of 85 to 86 per cent is finally obtained. The slimes are washed with one lot of wash water, which solution is discarded if it does not run over 40 cents per ton. The total time consumed in treating a tank of dust is generally about 72 hours, sometimes more, up to 120 hours, depending on the nature of the ore the mill is treating. It is interesting to note that the dust has a higher value than the ore from which it originates, and that the extraction is 5 to 6 per cent above that made on the sands, or the coarser material treated in the large vats, also that the time of treatment is considerably shorter, by more than a day.



Bottom Plan of Siphon.



AIR AGITATION AND SIPHONING DEVICE.

Scales $\frac{3}{4}$ inch = 1 foot.

$\frac{1}{2}$ inches = 1 foot.

The following table is a tabulation of the work of the mill on sands and dusts over a considerable period of time:

Lot Number.	Material.	Number of Tanks of Sands in 50 Ton Lots, Dust in 8 Ton Lots.	Average Value of Ore per Ton in Ounces Gold.	Average Extraction Made in Percentage, Determined on the Washed Tailings.	Average Percentage Saved; Determined on the Unwashed Tailings.	Average Time Consumed per Tank in Days.	Remarks.
1	Sands..	32	0.68	81.5	79.7	5.9	.....
2	Sands..	32	0.76	80.4	77.8	5.54	.....
3	Sands..	24	0.64	79.9	79.1	7.7	This lot was turned over in vats to aerate. (See text.)
4	Sands	25	0.51	81.3	79.4	5.75	
5	Dust...	36	1.18	89.6	86.2	4.4	.....
6	Dust...	22	0.86	87.6	85.0	3.7	.....

REMARKS ON THE TABLE. *Lot No. 1.*—This was first treated with 15 tons of strong solution, 5 pounds cyanide per ton of solution, followed by 3 tons of weak solution, 2 pounds cyanide per ton. This last was allowed to stand on the ore for 50 hours, and then followed by 22 tons of weak solution, put on in 5 ton lots as it drained off. Then this was followed by 8 tons of wash water, put on in 4 ton lots, then allowed to drain, after which vacuum was applied to take off as much moisture as possible. The total amount of solution used per tank was 48 tons.

Lot No. 3.—The amount of solution used in this lot was the same as in lot No. 1; but after 35 tons had been run through the pulp was shoveled over to supply oxygen and then treated with the balance of the solution. The extraction before the shoveling over was 75.7 per cent., and after the turning over and complete leaching 79.7 per cent. The ore in this lot was considerably baser than lot No. 1, and it is certain that the turning over

was of benefit, from previous experience on this class of ore. However, the extra time and labor balanced the extra extraction.

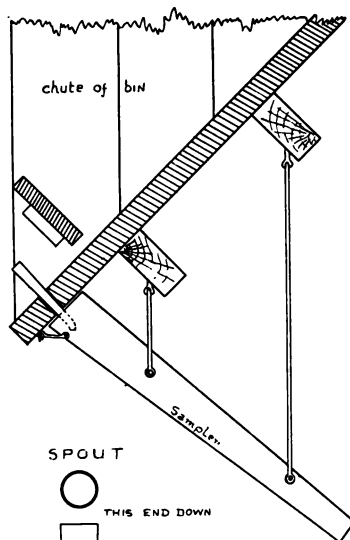
Lot No. 4.—This lot was moistened with 20 per cent of a 5 pound cyanide solution at the finished product bin. It was found that 66 to 73 per cent. of the values had gone into solution by the time the vat was levelled off. On this lower grade of ore this method gives a somewhat better extraction.

Moistening with a 2 pound solution was also tried, but it was not as effective as the stronger solution. The time of exposure at the bin was also varied, 12 hours and 48 hours being tried, and it was found that 12 hours accomplished as much as 48 hours.

Lots No. 5 and 6.—The treatment of these lots differed somewhat from that described under "Dust Treatment," in that all the solution used had a strength of but 2 pounds per ton. Five weak solutions and one wash water were used. The slimes were allowed to settle for 12 hours, then syphoned off, 50 to 60 per cent of the moisture being taken out, to be replaced again by fresh weak solution. Otherwise treatment was the same as described.

Further Remarks.—There has been considerable controversy in the Hills regarding the relative methods of wet and dry crushing, the wet crushing really being a question of fine crushing. It is an indisputable fact that in the greater part of the Potsdam ores the gold is very finely disseminated and that fine crushing is required to liberate it. Some of the above results would indicate that the fine material can be treated in somewhat less time, and with a higher extraction than the coarse sands, but with somewhat more trouble. The fine wet crushing method is coming into prominence, two mills being now in operation, which are described in this paper. It is a question whether fine crushing may not also be of advantage for those ores in which the gold is not so finely disseminated, in that by raising the extraction and possibly decreasing the time, in spite of the more complicated plant necessary, an economy could be instituted.

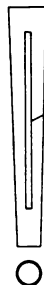
METHODS OF SAMPLING ORE, TAILINGS AND SOLUTIONS.—The ore that goes through the mill is automatically sampled at the finished product bin by the following device: A tin tube, 10 inches long, having a longitudinal slot $\frac{1}{4}$ inch wide, projects into the discharge spout of the bin. The material which enters this tube is discharged on an inclined shallow trough, provided with diagonal tin troughs, perforated with narrow slits at right angles to their length. Part of the material passes through the slits and



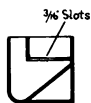
SPOUT



THIS END DOWN



1/4" Slot.

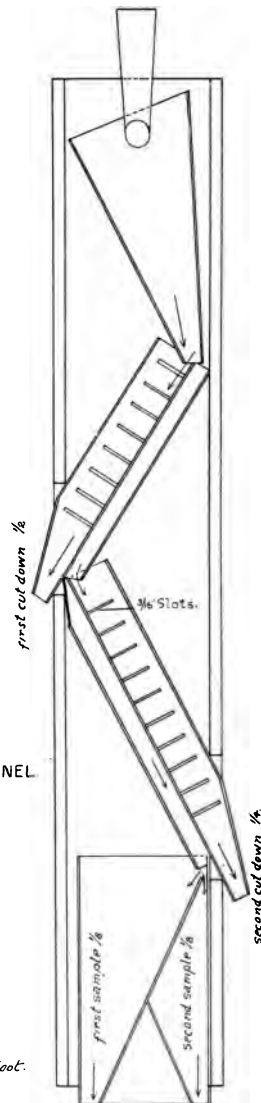


CROSS SECTION OF CHANNEL.

SAMPLING DEVICE.

Scale 3 inches = 1 foot.

1 inch = 1 foot.



PLAN OF SAMPLER

C. H. Fulton, G.S.M.

part over them, this last being discarded. What passes through the slit is deflected to a similar tin trough again, being halved as before, and what passes through is split into two equal parts by a deflecting sheet of tin, making a final duplicate sample. (See drawing for detail and further explanation.) This device samples automatically whenever the discharge spout of the bin is opened. The device has been checked against samples taken by coning and quartering from the bin product, and also by sampling the ore after it leaves the Gates crusher, taking out every tenth shovel and quartering this product down. It agrees very closely with both of these methods.

Sampling the Tailings.—The tailings are sampled in the vat by a pipe sampler, 20 samples being taken around the outside circumference. Two assays are made on this material, one on the washed sample and one on the sample before washing, to determine what goes to waste by retained solution.

Sampling the Solutions.—The solutions are sampled at the head and end of the box by means of drip samples. The elbow which turns the pipe into the boxes has a $\frac{1}{2}$ inch hole into which a cork fits, through which passes a bent glass tube, attached to which is a piece of rubber tubing. At the end of the tube is an adjustable clamp, which regulates the drip. The drip is caught in an old acid bottle, and by these means a very fair sample is obtained. In thus regulating the drip by an adjustable clamp a better sample is obtained than where no clamp is used, simply allowing the rubber tube to reach to the bottom of the bottle and letting the excess overflow, as is the practice in some mills.

THE METHOD OF TREATING THE PRECIPITATES.—The precipitates are separated in the clean up into the fine slimes and the coarser zinc thread which has been attacked enough to pay to treat. The fine material, after being thoroughly washed on the circular filter already mentioned, is treated with dilute sulphuric acid, 1 part acid to 2 parts water, until most of the zinc has been dissolved, then washed and dried and smelted with 75 per cent of its weight of the following flux: 4 parts of borax, 2 parts of soda, 1 part of nitre, 1 part of sand. While molten the fusion is thoroughly stirred with green wood, the same process known as "poling" in copper metallurgy. The product from this first melt is remelted with some borax and a little nitre to refine, a little bone ash being also added. The bullion contains very little silver and about 10 per cent of base metal. The fine slimes represent about 90 per cent of the value of the total precipitate.

The coarser material is first dried and then roasted at a dull red heat in a covered sheet iron pan, 10 square feet area and 10 inches high, which is set on a large wood-burning stove. The roasted product is then smelted directly with the addition of the above flux. The slag bottoms from the melts are crushed and panned, the pannings melted with lead and the button cupelled. The balance of the slag is sent to the smelter.

The table needs but little explanation. Many of the items are high, such as labor and repairs, but the mill is the oldest in the Hills and by no means a modern plant, and for that reason at a decided disadvantage. Some of the monthly costs are also high, due to the mill running much under its capacity. The cost of charging and discharging tanks is high—cost of charging tanks is 7 cents per ton; of discharging, 12 cents per ton.

The power for the mill is furnished by two boilers, return tubular, rated at 60 horse power, and a 55 horse power Buckeye engine. Cost of fuel at the mill is: Sheridan coal, \$4.25 per ton; mine run, \$3.50 per ton; 4-foot wood, \$3.60 per cord.

THE NUMBER OF MEN EMPLOYED AT THE MILL. --

DAY SHIFT.	NIGHT SHIFT.
1 crusher man.	1 crusher man.
1 dryer man.	1 dryer man.
1 roll man.	1 roll man.
1 oiler.	1 oiler.
1 engineer.	1 engineer.
1 blacksmith.	
1 solution man.	1 solution man.
2 shovellers.	
1 foreman.	
1 assayer.	
1 assayer's helper.	
1 superintendent.	

Making a total of 19 men.

DETAILED COST SHEET OF THE GOLDEN GATE MILL.—(Treating custom ore in a rented plant.)

MONTHS, 1900-1901.	Number of Tons Treated.	Cost per Ton, due to Labor.	Cost per Ton, due to Cyanide.	Cost per Ton, due to Zinc.	Cost per Ton, due to Lime.	Cost per Ton, due to Supplies (Tools).	Cost per Ton, due to Fuel (Coal).	Cost per Ton, due to Fuel (Wood for Dryer)	Cost per Ton, due to Lubricants.	Cost per Ton, due to Repairs.	Cost per Ton, due to Sundry Expenses.	Cost per Ton, due to Rent.	Cost per Ton, due to Insurance.	Cost per Ton, due to Superintendence and Assays.	Cost per Ton, due to General Supplies.	Cost per Ton, due to General Expense.	Total Cost per Ton.	Loss per Ton in Mill Extraction.*	Total Cost, Including Loss.
March.....	1100	1.49	0.36	0.068	0.01	0.116	0.36	0.106	0.07	0.69	0.01	0.318	0.07	0.242	0.082	0.232	\$4.259	\$2.179	\$6.138
April.....	1109	1.773	0.673	0.015	0.041	0.068	0.440	0.169	0.117	0.214	0.002	0.315	0.06	0.211	0.03	0.354	4.482	1.944	6.426
May.....	1544	1.412	0.55	0.072	0.021	0.068	0.382	0.187	0.103	0.528	0.001	0.227	0.042	0.148	0.018	0.308	4.10	2.533	6.637
June.....	808	1.693	0.162	0.085	0.028	0.165	0.452	0.127	0.079	0.436	0.008	0.134	0.095	0.305	0.11	0.308	4.517	2.588	7.105
July.....	1120	1.317	0.30	0.059	0.018	0.052	0.30	0.174	0.05	0.527	0.006	0.312	0.069	0.233	0.112	0.492	4.021	2.803	6.852
August....	778	1.704	0.324	0.076	0.022	0.078	0.143	0.164	0.06	0.405	0.005	0.590	0.095	0.440	0.122	0.329	4.718	2.445	7.199
September	781	1.626	0.33	0.116	0.029	0.046	0.397	0.126	0.06	0.367	0.038	0.447	0.094	0.321	0.102	0.335	4.433	1.032	5.50
October...	831	1.664	0.378	0.053	0.022	0.038	0.397	0.239	0.06	0.111	0.006	0.115	0.109	0.176	0.117	0.261	4.049	1.182	5.263
November.	940	1.632	0.28	0.07	0.025	0.114	0.458	0.206	0.06	0.303	0.004	0.372	0.060	0.138	0.11	0.175	4.077	1.404	5.508
January...	922	1.725	0.245	0.044	0.025	0.078	0.425	0.246	0.063	0.181	0.01	0.38	0.068	0.124	0.142	0.20	3.956	1.281	5.264
February..	464	2.305	0.257	0.097	0.045	0.133	0.834	0.41	0.069	0.03	.....	0.753	0.134	0.253	0.215	0.402	5.904	2.533	8.548

*Loss in mill extraction is figured as the difference between assay value of ore and bullion returns per ton of ore.

The Cyanide Plant of The Wasp No. 2 Mining Company.

SITUATED ON YELLOW CREEK, NEAR KIRK, S. D.

This is one of the recent mills, having been built during the early part of 1900, and beginning operations about September, 1900. It has been running continuously since then, and represents a modern plant, although improvements have been made recently, in increasing the capacity and in the method of filling the leaching vats. In comparison with the last described mill it shows the progress made in mill construction. It is a dry crushing mill, but has no facilities for drying the ore, there being but little necessity for that, due to the coarse crushing that is done and the dry nature of the ore. The mine is within 250 yards of the mill, the ore being transported in trains of 4 cars, by mule haulage. The cars hold 1500 pounds of ore, are of the end dump type, and discharge into the main storage bin, of small capacity, which feeds to the crusher floor.

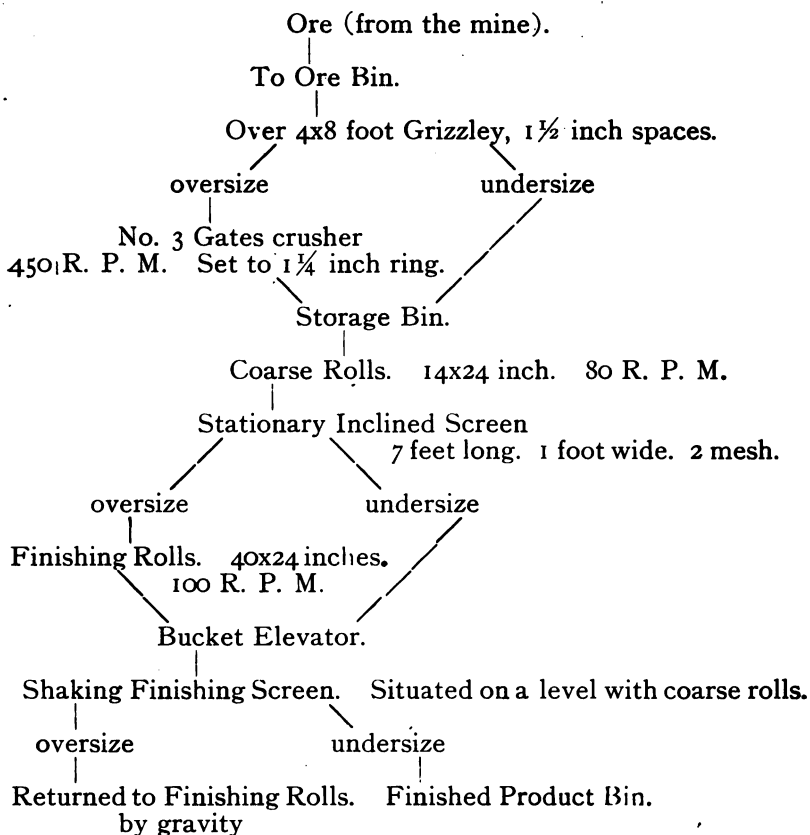
NATURE OF THE ORE TREATED.—The ore is of the quartzite variety from the Potsdam. In the greater part of the ore the gold is carried seemingly on the cleavage planes of the quartzite, and is not finely disseminated as is usually the case, although the mine also has some of this latter class of ore. The fact that the gold is carried in the cleavage planes makes coarse crushing permissible, manifestly a great advantage. Very little pyrite is present, but some antimony in the form of stibnite is found, although only in small quantities, not sufficient to cause trouble in the cyaniding. The value of the ore varies considerably, generally running between \$4 and \$20 per ton, the greater part being nearer the first figure than the last. The ore is at times quite acid, requiring considerable lime to neutralize it.

THE CRUSHING OF THE ORE.—The mill site is very favorably situated as regards slope, full advantage being taken of gravity, there being but one elevator in the mill. The capacity of the mill as built, was from 50 to 60 tons per day, but the installation of a new large tank raises this to 105 tons per day. |



CYANIDE MILL OF THE WASP NO. 2 MINING CO., YELLOW CREEK, S. D.

The following diagram illustrates the scheme of crushing:



THE CRUSHING AND SCREENING MACHINERY.—The Grizzly is 8 feet long, 4 feet wide, with 1 1/2 inch spaces. It is inclined at 45 degrees.

Coarse crushing is done in a No. 3 Gates crusher, breaking to a 1 1/4 inch ring. The capacity of the old No. 2 crusher was about 60 to 65 tons per 24 hours, and it was found necessary to put in a No. 3 Gates in order to come up to the increased tankage capacity when the new tank was installed. It has been found that a No. 2 Gates has a too limited capacity, even for a 60 ton mill, as the wet ore rapidly decreases its capacity. It is also the experience that the mouth openings are rather too small for the mine rock, so that too much sledging has to be done.

Coarse Rolls (1 set).—These are Gates rolls, 24 inches in diameter and 14 inch face, making 80 revolutions per minute.

The ore is fed to the rolls by Tulloch automatic feeds. The rolls are not housed, as the ore is damp enough to avoid much dust.

Finishing Rolls (1 set).—These are of the same make as above and the same size, but make 100 revolutions per minute. A Tulloch feed also supplies these rolls.

Stationary Inclined Screen.—This is 7 feet long, built in 2 partitions, each one foot wide, giving 14 square feet of screening surface. It is inclined at 45 degrees. It is 2 mesh wire cloth, or 4 openings per square inch.

Combined Shaking and Stationary Inclined Screen.—This is the finishing screen. The first 8 feet is a shaking screen and the balance, about 8 feet, being stationary. It is 2 feet wide, giving a screening surface of 32 square feet. It is $2\frac{1}{2}$ mesh. This inclined screen is on the principle of the Berthelet separator, the material passing through it being considerably finer than the mesh would indicate. Practically, the product passing through this screen is not above 6 mesh. This is the size of the material cyanided.

THE LEACHING DEPARTMENT OF THE MILL.—There are 4 leaching vats, 16 feet in diameter and 7 feet deep. The vats are of Oregon fir, $2\frac{1}{2}$ inch staves, bound by seven $\frac{5}{8}$ inch iron hoops. The capacity per vat is 55 tons of crushed dry ore. A new wooden 100 ton vat has lately been installed. The vats have a central discharge gate, 14x14 inches, discharging the tailings into launders underneath the tanks. The new vat is of larger size.

Below the leaching vats are situated the 2 gold solution storage tanks, 10 feet in diameter and 6 feet deep, also of Oregon fir, with $2\frac{1}{2}$ inch staves.

Below the gold solution storage tanks are placed the two sump tanks, of the same size and kind as the above. These tanks were used formerly for precipitation tanks, employing zinc dust as a precipitant. This, however, has recently been discontinued.

The 2 solution storage tanks are situated above the leaching vats, and are 10 feet in diameter and 10 feet deep, with $2\frac{1}{2}$ inch staves. The main solution pipe lines in the mill are $2\frac{1}{2}$ inches in diameter, each leaching vat being connected, as is customary, with both the strong and weak solution gold storage tanks. There is no vacuum connected with the leaching vats, as the coarseness of the ore permits of rapid leaching and good drainage. As already stated, when the mill began operations, precipitation by zinc dust was employed; this, however, was discontinued

for reasons discussed further on, and at present precipitation is carried on in wooden barrels by means of zinc shavings. There are 5 barrels for the strong solution and 6 barrels for the weak solution, the barrels being 3 feet deep and 2 feet in diameter at the middle. They are provided with a screen at the bottom, on which the zinc rests, and a rectangular compartment on one side, 8 by 4 inches, by which solution descends below the screen, rising up through the zinc as in the ordinary form of precipitation boxes. The advantages claimed for the barrels are: *1st*, that the round shape tends to avoid channeling, which causes irregular precipitation, and, *2nd*, that the clean-up is much facilitated, because the barrels can be handled individually.

THE CYANIDING OF THE ORES.—The leaching vats are charged by means of a belt conveyor, which takes the ore from the finished product bin and carries it to the five leaching vats. This belt conveyor was installed recently, the mill as originally designed having the vats filled by end dump cars running on tracks over the vats. The conveyor is in two parts, that is, there are practically two conveyors placed at right angles to each other. This is necessitated from the fact that the vats are placed in a row at right angles to the discharge end of the bin. The reader is referred to the diagrammatic sketch for further explanation. The conveyor proper is a 16 inch rubber belt, the first conveyor 50 feet long and the second, 40 feet long. The speed of the belt is 600 feet per minute. By these means a vat is charged in from 2 to 2½ hours, accomplishing a great saving in time over the old method of charging by cars. The tailings are discharged from the vats by sluicing with a water pressure of 60 to 65 pounds per square inch. The time needed to discharge a vat is 2½ to 3 hours. The favorable situation of the mill gives unlimited grade to carry off the tailings.

While the vat is filling, and about one-half full, the strong solution is turned on, 6 pounds of Potassium Cyanide per ton of solution. The amount of strong solution run on is about 15 tons, which is allowed to stand 3 to 4 hours generally, sometimes much longer, according to the nature of the ore. When the strong solution is started draining, the weak solution is run on and is allowed to remain undisturbed in contact with the ore for at least one hour; then leaching is started, fresh weak solution being continually added to replace that which drains off, until wash water is applied. The weak solution contains 2½ to 3 pounds of cyanide per ton. The amount of weak solution thus

brought into contact with this ore is from 40 to 50 tons. When the gold value of the weak solution does not run above 30 to 50 cents per ton, the wash water is applied. The amount of wash water is about 6 to 9 tons. The total time consumed is about 96 to 100 hours, including the charging and discharging of the tanks. The total amount of the solution used, including the wash water, is 70 to 75 tons per vat.

The amount of lime used to neutralize the acidity of the ore and give the requisite protective alkalinity to the solution is 6 pounds per ton of ore. This is added unslacked on the cars, before the ore is dumped into the first bin.

The protective alkalinity is afforded by $2\frac{1}{2}$ pounds of lime per ton of solution.

The consumption of cyanide is 0.63 pounds per ton of ore, and the actual extraction ranges between 80 and 85 per cent of the values contained in the ore.

THE PRECIPITATION BY ZINC THREAD AND THE CLEAN-UP.—

The precipitation by zinc is practically perfect, but little trouble of any kind being experienced; the rate of flow of both weak and strong solution through the barrels is 3 tons per hour. The tailings solution issuing from the barrels runs from 4 to 10 cents per ton.

The barrels are all provided with a strap on each side, so that they can easily be lifted. When ready for the clean-up the barrels are hoisted up and dumped into one of the gold solution storage tanks, which has been emptied for the purpose. The men get right into the tank and wash the precipitates, taking out all the material that will not pass a 10 mesh screen. This is put back into the barrels. The fine material in the tank is then pumped through a Johnson filter press, having 2x2 foot frames, which was formerly used in the zinc dust precipitation. The precipitates are thoroughly washed in the press and then partly dried by forcing air through the press. Then the precipitates are discharged and are ready for the acid treatment.

A small Worthington duplex pump operates the filter press by water pressure. An air pump can also be connected, so as to force air through the filter press. The precipitates, after the drying, are charged into the acid tank, which is 4 by 4 feet in cross section and 5 feet deep, lined with heavy sheet lead. It is provided on the inside with several coils of $\frac{1}{2}$ inch lead pipe, carrying steam to heat the acid if necessary. The bottom of the tank has a slight slope toward the discharge opening, a 1 inch

lead pipe in the bottom. The acid tank is provided with a close covered hood, which can be raised and lowered, to facilitate charging. The precipitates are treated with dilute sulphuric acid, of the usual strength, long enough to dissolve the zinc, then allowed to settle and the solution syphoned off. Then water is added and the mixture is pumped back through the filter press. Here it is again thoroughly washed with water, then dried with air. The dried precipitates are then heated to a dull red in sheet-iron pans, 2x4 feet in size, in a large iron muffle, then smelted in graphite crucibles with the following flux: seventy parts crude borax, 35 parts soda and 20 parts of sand. The consumption of zinc is 0.9 pound per ounce of bullion produced.

THE PRECIPITATION BY ZINC DUST AS FORMERLY CARRIED ON. —As already mentioned, the precipitation by means of zinc dust was carried on in the sump tanks. These tanks for this purpose were provided at the bottom with a perforated circular iron pipe, connected with the air pump. The bottoms of the tanks were inclined $\frac{1}{2}$ inch per foot toward the discharge pipe to insure complete drainage. When the tanks had filled with gold-bearing solution the air was turned on, giving the solution a circular motion, with also ascending and descending currents. The air pressure used was 45 pounds per square inch. Then zinc dust was added in the form of an emulsion around the edge of the tank and the contents of the tank agitated by air for 10 minutes. Then the material was pumped through the filter press, leaving some of the zinc dust and precipitates in the bottom. The amount of zinc dust used to start with, was 1 pound per ton of solution. This was gradually reduced to $\frac{1}{2}$ pound for the strong solutions and $\frac{1}{3}$ pound for the weak solutions in succeeding precipitations. It took two hours to pump 12 tons of solution (the amount usually precipitated) through the filter press. The tailings solution from the filter press usually had a value of about 10 cents per ton, showing that the precipitation was good.

The objections to the method arose in treating the precipitates taken from the presses. These usually packed very hard, so that it was difficult to disintegrate them for the acid treatment. It was found that the dilute sulphuric acid would attack the dust precipitates but very slightly, it being practically impossible to get the zinc out. This fact may be due to the coating of metallic gold on the zinc particles, protecting them from the acid. (At the Golden Gate mill in Utah and in several other

plants where the process is in use, a mixture of sulphuric and nitric acids is used, seemingly with success.) Finally the acid treatment was discarded and the zinc precipitates were roasted and then smelted. The usual zinc thread precipitation then replaced the zinc dust precipitation.

METHODS OF SAMPLING ORE, TAILINGS AND SOLUTIONS.—The pulp is sampled at the finished product bin by the following device: The belt of the conveyor has one hole on the center line of the belt, and every time this comes under the discharge spout of the bin some of the pulp shoots through, falling on the apex formed by two slant boards coming together under the center line of the belt. This divides the material into two samples, which are collected on the floor or in large boxes. No information is available as to the accuracy of the sample thus obtained.

Sampling the Tailings.—The tailings are sampled by pipe sampler, 4 samples being taken irregularly distributed over the surface of the vat. After sluicing has commenced a face sample is taken at the center of the vat.

Sampling the Solutions.—The solution pipes entering the gold solution storage tanks and leaving the zinc boxes are tapped by cork and a small rubber tube as described for the Golden Gate mill. No clamp is used, however, and the tube dips to the bottom of a 5 gallon stone jar, the overflow going back into the tanks. When the gold solution tank has been filled, the solution man dips to the bottom of the jar with a dipper and fills a small bottle, which goes to the assay office. The jar is then emptied and placed for another sample. This method is probably not as accurate as the one described for the Golden Gate mill, but it has been the experience that sampling the solutions with the object of keeping a check on the amount of gold extracted as indicated by the heads and tailings assays of the pulp, is not possible, and solutions are assayed mainly to keep track of the leaching and precipitation.

THE POWER PLANT OF THE MILL.—Steam is furnished by 2 Erie return tubular boilers, 75 horse power. The engine is a Sioux Corliss, 12x36 inch cylinder, 85 revolutions per minute, steam at 85 pounds per square inch. A separate small upright engine furnishes the power for the conveyor and for the dynamo for electric lighting.

THE NUMBER OF MEN EMPLOYED IN THE MILL.—

DAY SHIFT.	NIGHT SHIFT.
1 crusher man.	1 roll man (takes rolls

I roll man.	and crusher).
I engineer.	I engineer.
I tank man.	
I solution man.	I solution man.
I millwright.	
I superintendent.	
I assayer.	

Total, 11 men. This figure applies while the mill was treating 65 tons per day. Wages for engineers are \$3.50 per day; other mill labor, \$3 per day.

THE COST OF CYANIDING.—The cost of cyaniding is \$0.832 per ton, in detail as follows:

Labor.....	\$0.411
Cyanide.....	.188
Zinc.....	.031
Repairs.....	.086
Fuel.....	.116
Total	\$0.832

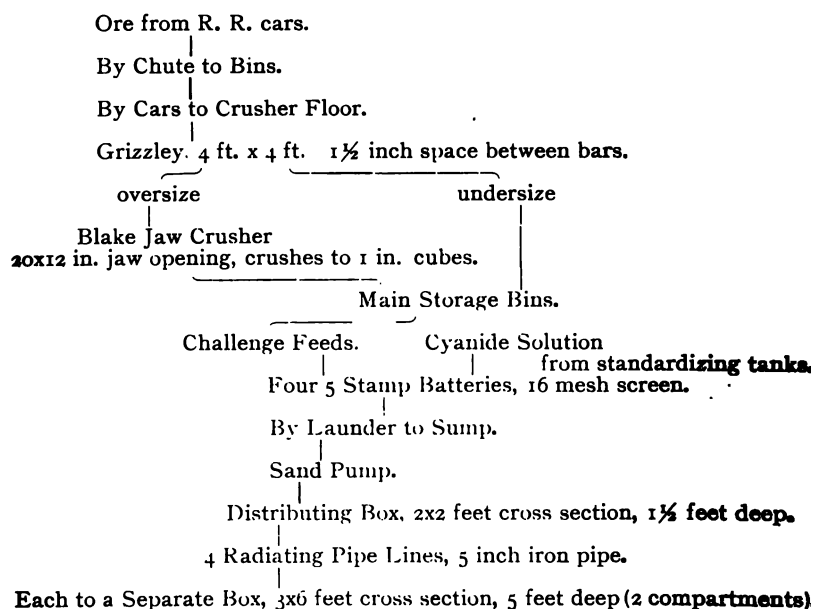
The figure stated was for the month of October, 1901, when 3294 tons were treated, making a daily average of 106 tons.

The Portland Cyanide Mill.

This mill is located at Gayville, at the mouth of Blacktail Gulch, a short distance from Central. It was originally a stamp amalgamation mill, but as this process could not treat the ores from Portland successfully, cyaniding was installed. The mill is a wet crushing mill, crushing with cyanide solution in the battery, separating the resultant slimes and sands and treating each separately. The mill has been in operation as a cyanide plant since about October, 1900, at that time having a capacity of 30 tons per day, this being the limit, due to the lack of facilities for handling more slimes. More tankage was then provided for and the capacity of the mill is now 60 tons of ore per day. The ore treated comes from the Portland district.

THE NATURE OF THE ORE TREATED—The ore is from the Potsdam and is very siliceous, possessing the characteristics already described, except that the gold in this case is very finely disseminated and fine crushing is required to liberate it. Most of the ore treated is well oxydized.

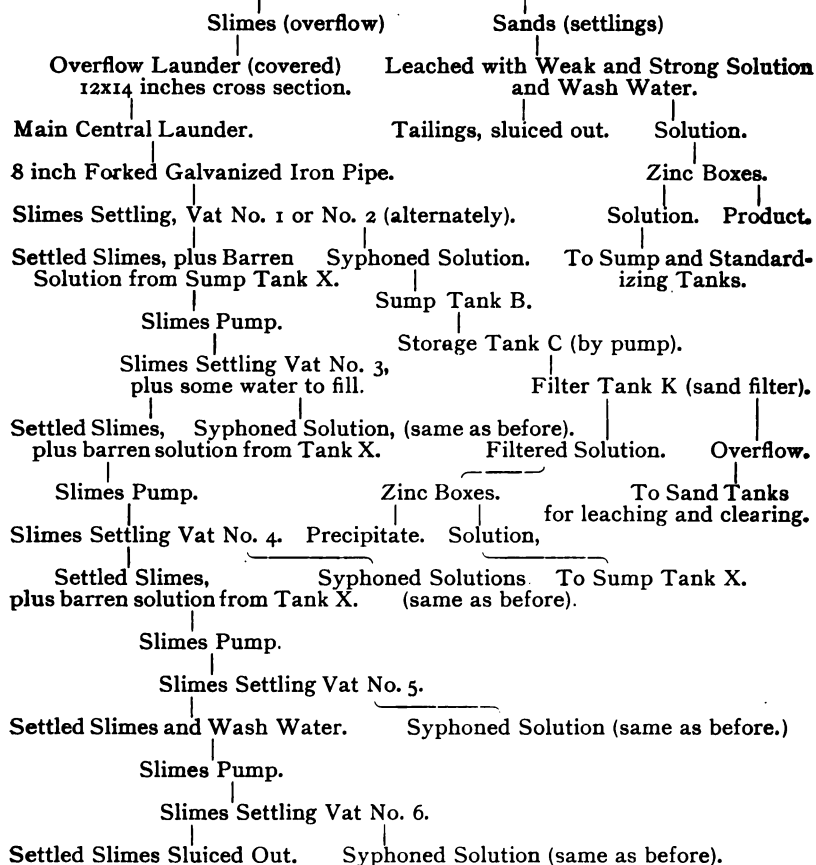
THE WORKING SCHEME OF THE PORTLAND MILL.—





CYANIDE MILL OF THE PORTLAND MINING CO., GAYVILLE, S. D.

Each to a Separate Box, 3x6 feet cross section, 5 feet deep (2 compartments).

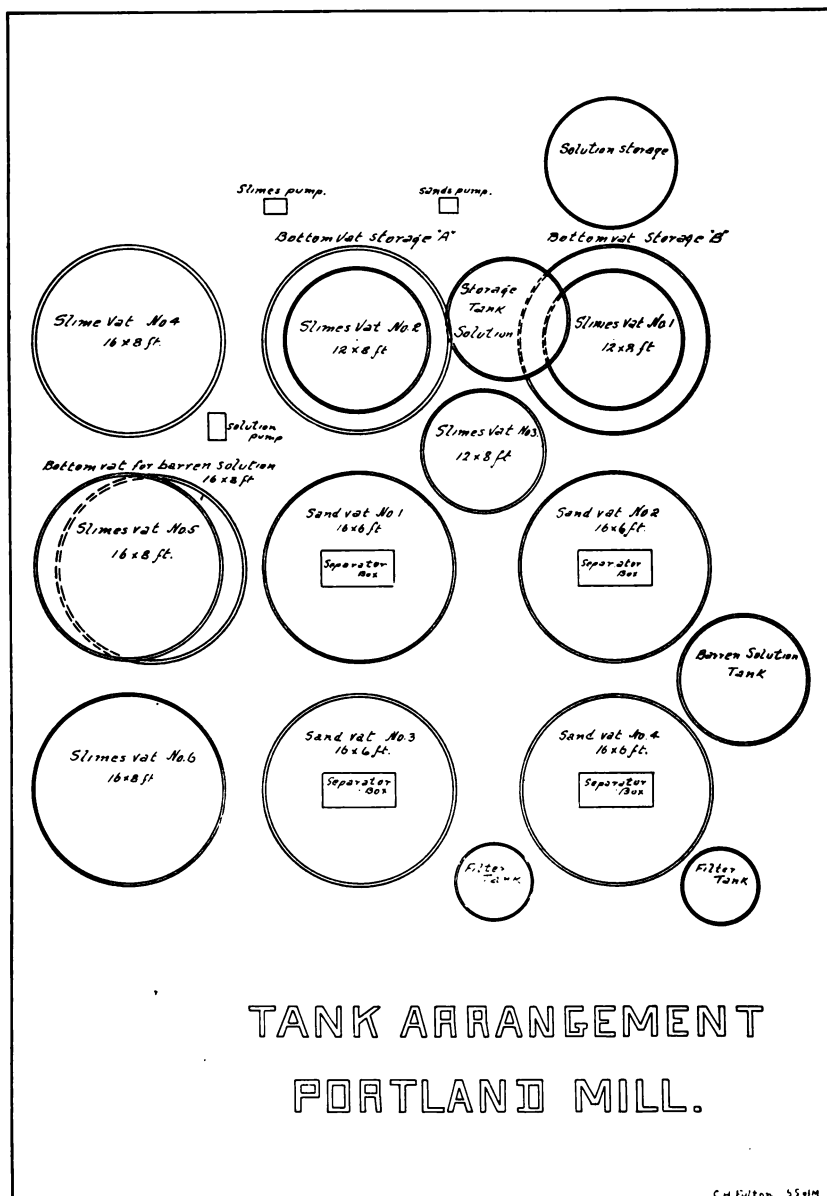


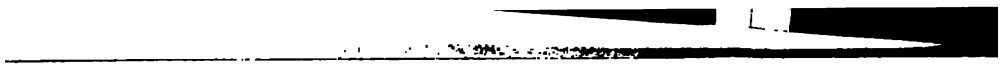
THE CRUSHING MACHINERY.—The Grizzley is a short one, 4 feet long and 4 feet wide, just above the jaw crusher. The spaces are 1½ inches wide. The rough crushing is done in a Blake jaw crusher, having a jaw opening 20x12 inches, and hence the ore requires very little sledging, and for this reason the crusher possesses a decided advantage over the smaller size gyratory crushers. This crusher crushes the 60 tons that pass through the mill in 7 to 8 hours, avoiding a night crusher shift. The ore is taken from the main storage bins, which are fed by the crusher, by 4 challenge feeds and fed to the 4 batteries of 5 stamps each. The stamps are 900 pound stamps, 100 drops per minute, crushing through a 16 mesh screen with a 2 to 2¼ pound cyanide solution. The amount of solution is about 4 tons per ton of ore

crushed. The screens are covered with canvas to avoid splash, the solution being caught in a longitudinal launder, which carries it to the Frenier sand pump, which elevates it above the tanks. (See the working scheme.)

THE SEPARATION OF THE SANDS FROM THE SLIMES.—The Frenier sand pump sends the pulp to the distributing tank, a water-tight wooden box, 2x2 feet in cross section, from which radiate four 5 inch iron pipes, each of which can be cut out as desired, one going to the separator box suspended over each sand vat. The separator boxes are 3 feet wide by 6 feet long and 5 feet deep, made water tight by a double lining and divided into two compartments, so that each compartment is 3 by 3 feet in cross section and 5 feet deep. Each compartment has a 12 inch circular discharge gate in the bottom, which is closed tight against its frame by a rubber gasket. This gate is similar to a type of bottom discharge gates for cyanide vats. The pulp is led into one compartment, the sands settling out, while the slimes overflow by a side gate into a covered launder, 12 inches wide and 4 inches deep, which in turn discharges into the main central launder, taking the slimes from all four of the separator boxes. (Only one box, however, is in use at a time.) This main central launder ends in a forked 8 inch galvanized iron pipe, so that the pulp can be discharged into either slime vat No. 1 or No. 2, according to which one is empty and ready for the charge. Whenever one compartment of a separator box is full, the pulp is deflected to the other compartment, while the accumulated sands are discharged into the sand vat below by means of the bottom discharge gate. When crushing through a 16 mesh screen the amount of slimes is about 40 to 50 per cent of the ore crushed.

THE TANK CAPACITY OF THE MILL (see plan of tanks).—There are 4 sand leaching vats, of cedar, 16 feet in diameter and 6 feet deep. In all there are 6 slime vats, 3 of which are 16 feet in diameter and 8 feet deep, 2 are 12 feet in diameter and 8 feet deep and 1 is 10 feet in diameter and 8 feet deep. There are 4 tanks for the storage of solution, 2 of which are standardizing tanks and 2 are tanks which hold the syphoned solutions from the slime vats before it goes to the filter tanks. They are approximately the size of the smaller slime vats. There are also two sump tanks, or barren solution storage tanks. "Barren solution" is the solution as it issues from the extractor boxes, low in free cyanide. This is the solution with which the slimes are treated





after their first settling. These sump tanks are 16 feet in diameter and 8 feet deep. The filter tanks are 2 in number, about 6 feet in diameter and shallow, provided with a sand and gravel filter. The filtered solution goes to the zinc boxes, while the overflow (when there is any) goes to the sand vats as weak solution.

THE TREATMENT OF THE SANDS.—It takes about 36 hours to charge a tank by means of the separator boxes. The tank is then allowed to drain for about 6 hours, after which strong solution, about 3 pounds of cyanide per ton, is run on and allowed to stand for 8 hours. Then battery or syphoned solution is circulated for a varying length of time, to be finally replaced by about 4 tons of wash water. The tailings are sluiced out in about 2 to 2½ hours. The total time of treatment is in the neighborhood of 8 days. The capacity of the sand vats is 65 tons.

THE TREATMENT OF SLIMES.—The slimes as they come from the separator boxes are discharged into either slimes vat No. 1 or 2, whichever happens to be free, and when this is filled the slimes are deflected to the other one. About 5 pounds of lime per ton of ore is added at the stamps and greatly aids in the settling of the slimes. It takes about 10 to 12 hours for a vat of slimes to settle. Then the supernatant solution is syphoned off, the solution running by gravity to either one of the storage tanks. The syphon is a 2½ inch iron pipe with a T fitting at the end, supported on a wooden float. The 2½ inch pipe joins the discharge pipe, going out at the center of the bottom of the tank, by an elbow and a tee, so that it can turn on the thread and rise or fall with the solution. (See drawing of syphon arrangement.) After the solution has been syphoned off as closely as possible, "barren" or sump solution is pumped into the vat, and when filled the resultant mixture is transferred by the slimes pump to slimes vat No. 3. The pulp is discharged from the vat by means of two 3 inch pipes in the bottom, which lead to the pump.

In the 3rd slime vat the process is practically repeated, the slimes settling and the solution being syphoned off. In this and succeeding vats the method of running on barren solution or water after the first solution has been syphoned off, varies. The barren solution, or water, is introduced by pipes which run to the bottom of the vat, the ends being provided with nozzles, so that the velocity of the discharge will serve to agitate the pulp while the solution is being run on. Two of the charging pipes descend on the sides of the vat, while one descends at the center.

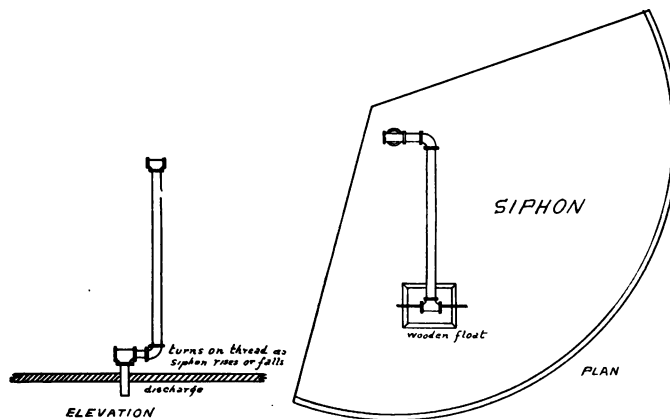
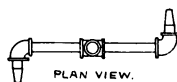
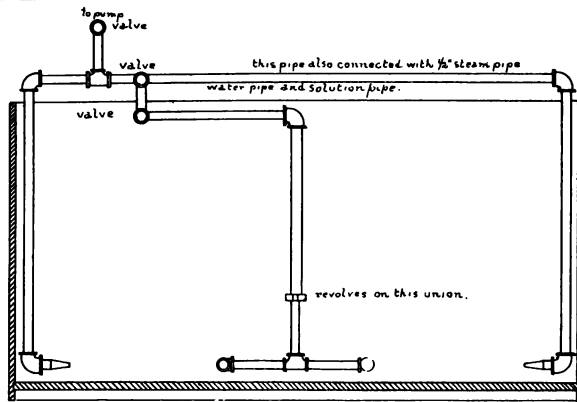
This last is joined to horizontal pipes at right angles to it, by a union, so that it can revolve, the whole similar to a garden sprinkler. This device serves to agitate the pulp while solution is being run on. The system of pipes is also connected with a $\frac{1}{2}$ inch steam pipe, so that steam can be introduced to raise the temperature of the mixture. (See drawing of agitating device.)

In this way the slimes are made to pass through 5 vats, wash water being added in the 5th vat instead of barren solution. The resultant material is then pumped to the 6th vat, where the slimes are settled and the solution syphoned off again. The slimes are then discharged by sluicing. The slimes retain about 100 per cent moisture, it not being possible to syphon off closer than that.

A Frenier spiral sand pump is used to circulate the slimes pulp from one vat to another. Two of these pumps are used, one for the slimes alone and one for raising the pulp from the batteries to the separator boxes. No information is available as regards the extraction made on slimes or sands. It is higher on slimes than on sands, but questionable whether as much is saved. (See the Dakota mill extraction figures.)

THE PRECIPITATION OF THE GOLD CYANIDE SOLUTIONS.—There are two zinc boxes, and on account of the large volume of the solution from the slimes treatment, both are used indiscriminately for both weak and strong solutions. The boxes contain 8 compartments, which are all filled with zinc, and are 2x2 feet in cross section and 20 inches deep. They are provided with side launders for clean-up facilities. Lately these zinc boxes have been replaced in part by ordinary whiskey barrels, similar to the plan described for the Wasp No. 2. The precipitation is good, as usual in the district, only that the boxes contain considerable fine sediment from the slimes treatment, which, however, does not seem to affect the precipitation any. The precipitates often contain considerable silver.

The clean-up is carried on bi-monthly. The slimes are transferred to a small filter tank of the general pattern and washed thoroughly, then transferred to a rectangular sheet-iron drying pan and steam dried. The steam drying device is of galvanized iron, in which the exhaust steam from the mill engine is used. (See drawing of steam drying device.) The precipitates after drying are treated with dilute sulphuric acid in the usual way and smelted. Before this method was installed the dried precipitates were sold to the Omaha smelters.



SIPHON AND AGITATING DEVICE.

METHOD OF SAMPLING THE SLIMES.—The first sample of the slimes is taken at the overflow of the separator boxes by taking a dipperful out at intervals of a half hour. The material thus taken out is collected in a large pail. When the sample is ready to go to the assay office the pail is half emptied, after thorough stirring, the remaining half being the assay sample. A second sample is taken from the last slimes vat before the slimes are finally sluiced out.

THE POWER PLANT OF THE MILL.—The steam is furnished by a return tubular boiler, burning mine run coal, forced draft being employed. The engine is an Erie mill engine, slide valve pattern, built by Frazer & Chalmers, Chicago, 60 horse power, cylinder 10x18 inches, 150 revolutions per minute, steam at boiler, usually at 80 pounds.

THE NUMBER OF MEN EMPLOYED IN THE MILL.—

DAY SHIFT.

NIGHT SHIFT.

1 crusher man.

1 battery man.

1 solution man.

1 engineer.

1 slimes man.

1 assayer.

1 assayer's helper.

1 foreman.

1 battery man.

1 solution man.

1 engineer.

A total of 11 men.

The figures for cost at this mill are not available, nor those for the value of the ore. Judging from experiments made at the Shawmut mill the cost is probably in the neighborhood of \$1.50 to \$2.00 per ton.

The Cyanide Plant of the Dakota Mining and Milling Company.

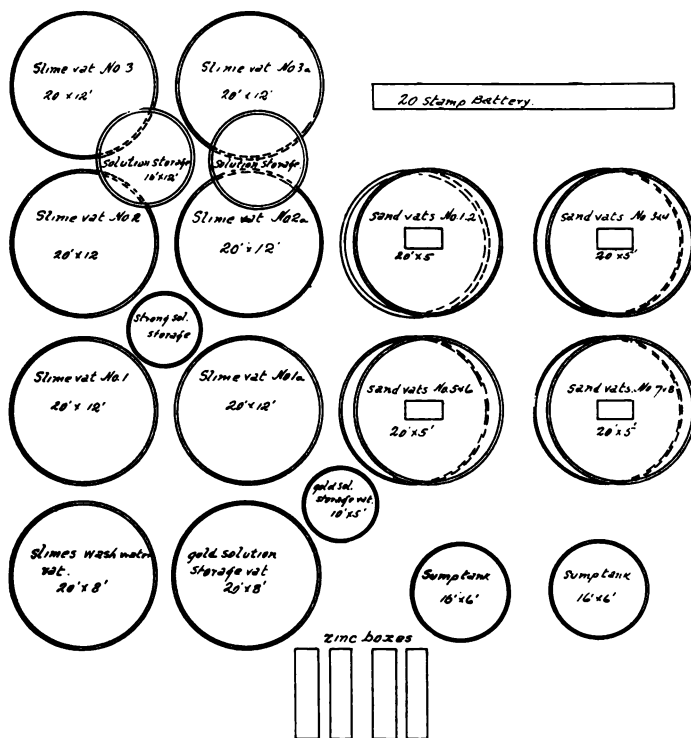
This cyanide plant is situated in the First Ward of Deadwood, and is the most recent plant but one to begin operations. It was constructed during the summer and fall of 1901 and went into commission in October. The mill is a wet fine crushing mill, having a capacity of 60 tons in 24 hours. The Portland mill at Gayville, already described, and the Shawmut mill, served in part as models for the mill. The method of treatment has been described in some detail in the description of the Portland plant.

THE CRUSHING OF THE ORE.—The ore goes from the bins, which are filled from railroad cars, to a Gates No. 4 D crusher, passing, however, first over the grizzly. The crushed ore is carried by elevator to the main storage bins, from which it is fed by suspended Challenge feeds to four 5 stamp batteries. The weight of the stamps is 900 pounds, the crushing being done through a 20 mesh woven wire screen. The mortars have a double discharge, and instead of being the ordinary lip mortar are provided with a gutter below the screens, cast as one piece with the mortar. These gutters take the pulp discharge from the batteries and send it to the charge box of the spiral pump. A heavy canvas is hung over the screen and gutter to prevent splashing.

Four pounds of lime per ton are added at the battery to aid in the subsequent settling of the slimes, there being but little acidity present. The ore is crushed with a 0.1 per cent, or 2 pounds of cyanide per ton solution, known as "battery solution."

It has been found necessary to close up some of the rear discharges of the batteries in order to keep the amount of battery solution down to the normal amount.

THE SEPARATING OF THE SANDS FROM THE SLIMES.—The pulp from the batteries is lifted by a Frenier sand pump (capacity 6000 gallons per hour) to the launders feeding the separator boxes. The height of lift is about 17 feet. The separator boxes,



TANK ARRANGEMENT DAKOTA MILL.



which separate the sands and slimes, are 5x4 feet in cross section and 5 feet deep, of the pattern already described for the Portland mill. The slimes in the overflow go to the slimes vats, while the sands are discharged at intervals into the vats directly below the boxes.

THE TANK CAPACITY OF THE MILL.—There are 8 leaching vats, built in 4 tiers of 2 each, for the double treatment of the sands. The vats are of red cedar, 20 feet in diameter and 5 feet deep. The sands, after leaching in the upper vats, are discharged into the vats beneath by bottom discharge gates.

There are 6 slimes vats, built in 2 rows of 3 each, each 3 vats comprising a unit for the treatment of one lot of slimes. The vats are 20 feet in diameter and 12 feet deep, 2½ inch staves, and built of red cedar. There are 2 sump tanks, 16 feet in diameter and 6 feet deep; 2 gold solution tanks, one 20 feet in diameter and 8 feet deep, the other 10 feet in diameter and 5 feet deep. Then there are two weak solution storage tanks, 16 feet in diameter and 12 feet deep, and also a strong solution storage tank, 12 feet in diameter and 7 feet deep. All these tanks are of red cedar. There is one tank 20 feet in diameter and 8 feet deep used as a settling tank to settle out sediment from the syphoned slimes solution.

THE TREATMENT OF THE SANDS.—The sand vats are charged in about 24 hours, by means of the separator boxes, and the pulp is then leached with a 0.2 per cent, or 4 pound cyanide solution, followed by the weak solution of 2 pounds per ton. The sands are then transferred, by shovelling through the bottom discharge gates into the second vat below. This transference takes about 12 hours and costs about 5 cents per ton. In the second vat the sands are leached again, the extraction made by the second leaching being about 8 per cent. The tailings are discharged by sluicing, the time consumed in discharging being about 2 hours. The total time consumed in treating sands, including charging and discharging vats, is 5 days. The extraction made on sands varies with the different ores treated, averaging about 83 to 84 per cent.

THE TREATMENT OF THE SLIMES.—The slimes, coming from the separator boxes, flow into one of the two lowest slime vats (Nos. 1 and 2 on tank plan). When one of these vats is filled (the filling being done by carrying the slimes to the bottom of the vat by a wooden pipe), the syphon is started and the solution syphoned off, fresh slimes pulp meanwhile running into the vat

continually. This can be done, as the slimes settle very rapidly with most of the ores treated at the mill. When so much slime has been charged into the vat that the syphoned solution begins to be seriously discolored, 25 pounds of slacked lime are fed into the launder taking the slimes overflow from the separator boxes, and when this has been carried into the slimes vat, the pulp is changed into the lowest slime vat of the second unit, where the above operation is repeated. The slimes in vat No. 1 are then allowed to settle for one hour, when the syphon is again started, and now follows the settling of the slimes down until the solution has been drained within a few inches of the settled slimes. The total time of settling is about 10 hours. The settled slimes in this vat are now sluiced out with "barren solution" to the centrifugal pump, which lifts the material to the next slime vat of the unit. When the vat has been filled the pulp is drawn off at the bottom by the centrifugal pump and returned to the vat over the top. This circulation is carried on for an hour. Then the slimes are allowed to settle, the clear solution at the top being syphoned off during the settling. When the slimes have settled, fresh barren solution is added and they are circulated by the centrifugal pump for another hour, 25 pounds more of lime being added in the course of the pumping. The slimes are then again allowed to settle, while the solution is syphoned off as before. When settling is complete the slimes are sluiced out with wash water to the centrifugal pump, which now raises the pulp to the last slime vat of the unit. Here the slimes are allowed to settle again and the solution syphoned off. After the solution has been drawn off wash water is added by a nozzle and pipe device situated in the vat, similar to the one described for the Portland mill. This serves to thoroughly wash and agitate the slimes for the last time. The slimes are now allowed to settle, while the solution is drawn off by the syphon. Then the slimes are sluiced out to waste, having passed through three vats. The syphon used is very similar to that described for the Portland mill, only in place of the discharge pipe passing out through the bottom, this one passes out through the side of the vat. The extraction made on slimes is about 88 per cent, but at present only about 80 to 82 per cent is saved, the balance passing out in the tailings in the retained moisture. More thorough washing, with facilities for handling this increased bulk of wash water, will undoubtedly raise the percentage saved. The total time consumed is about six days.

THE PRECIPITATING DEPARTMENT.—Precipitation is carried on in 4 zinc boxes, 2 for syphoned solution and 2 for sands solution. They are 10 compartment boxes, each compartment having a cross section of 20x15 inches and a depth of about 18 inches. Some extra precipitating barrels are being put in to accommodate an increased amount of solution. The precipitates can be sluiced from the boxes to the acid treatment tank, where they are washed and treated with dilute sulphuric acid in the usual way, transferred to a filter tank, filtered, washed and dried, and then smelted. The slags are treated at the Golden Reward smelter.

The precipitation in the boxes is good for both sands and slimes solutions, the slimes solutions usually carrying from .05 to .08 per cent free cyanide. Considerable sediment sometimes accumulates in the boxes, but does not seem to give any trouble in precipitation.

THE NATURE OF THE ORE TREATED.—The ores treated at the mill come mainly from the vicinity of Portland, and are siliceous Potsdam ores, with the values very finely distributed. The ore is very similar to what the Portland mill treats. The mill also treats custom ores to a considerable extent. Recently some siliceous ores have been treated which were but slightly oxidized, seemingly with considerable success.

The method of slimes treatment described is due to Mr. Empson, the superintendent of the mill.

The Highland Chief Cyanide Plant.*

The mill is situated near the mouth of Spruce Gulch, in Deadwood, and is the property of the Highland Chief Mining Company, of Chicago. The mill was built as a stamp mill, but has been recently converted into a wet crushing cyanide plant. It has a capacity of 40 to 50 tons per day, but at present is running only at half capacity, as changes are still being made. The general plan of operations is practically that carried out by the Portland and Dakota mills.

NATURE OF THE ORE.—The ore is the usual siliceous ore, already frequently described, and varies in value, the average at present treated being from \$8 to \$10 per ton.

THE CRUSHING OF THE ORE.—The ore is crushed by four 5 stamp batteries through a 20 mesh screen, with cyanide solution containing 0.04 per cent potassium cyanide per ton, which is unquestionably the weakest solution used in the district. A solution containing but 0.03 per cent has been successfully used, but was somewhat too slow in its action. All of the pulp coming from the batteries pass a 20 mesh screen, the slimes all being practically above 150 mesh. The sands, which are cyanided by percolation, are constituted as follows:

On 20 mesh.....	14 per cent
On 40 mesh.....	31 per cent
On 60 mesh.....	25 per cent
On 100 mesh.....	18 per cent
On 150 mesh.....	12 per cent

The pulp is elevated from the battery sump to the separator boxes by an 11 foot tailings wheel, instead of by the sand pump usually employed in the district.

THE TREATMENT OF THE SANDS.—The sands, which amount to 70 per cent of the ore, are charged into the leaching vats, which have 6 foot staves, in the usual way, and although rather fine, as the above figures show, still leach very readily, about 20 tons of solution leaching through in 24 hours. But little solution of extra strength is used on the sands, in fact, during the greater part of the leaching, battery solution (0.03 to 0.04 per cent) is used on them in order to keep down the surplus of solution. About 48 per cent of the values of the sands are extracted during the crushing in the battery. The total extrac-

*The writer is indebted for the following facts to Mr. John Randall, chemist of the Highland Chief Mining Company.

tion is high, slightly above 90 per cent, as the following assays will show:

	Heads.	Tails.	Extraction.
Vat No. 1.....	\$9.20	\$0.60	93.5 per cent
Vat No. 2.....	9.00	0.80	91.2 per cent
Vat No 3.	11.20	1.10	90.2 per cent

Total time of leaching is 6 days, during which time the solution is continuously circulated.

THE TREATMENT OF THE SLIMES.—The extraction of the values from the slimes is said to be practically complete in the battery, so that the washing out of the battery solution is about all that the slimes require. The amount of battery solution used is so adjusted that it rarely rises above \$2.50 per ton in value. This point is essential, as the complete washing out of the battery solution from the slimes is next to impossible, owing to the great amount of wash water that would be required, and hence the lower the value of the battery solution the less the loss. After the first settling and decantation the slimes, which still retain about their own weight of battery solution (that is, 8 tons of slimes retain 8 tons of solution), are pumped to the next vat with 12 tons of "barren solution" from the zinc sump. When this solution has been syphoned off after settling, 8 tons of wash water are added, the slimes allowed to settle and this also syphoned off. Then the slimes are discharged, usually carrying their own weight of retained solution, which usually has a value of about 75 cents per ton, and goes to waste. The last syphoning from the slimes is decanted to the battery solution, and does not pass directly to the extractor boxes. The slimes amount to 30 per cent of the ore.

The mill will probably soon be arranged to give the slimes another wash with barren solution, thus treating the slimes twice with barren solution and once with wash water. This last wash water, instead of being decanted to the battery solution, will be used as a first wash on the next lot of slimes. By this improvement the saving of the values from the slimes will be materially increased.

The precipitates from the zinc boxes, after the acid treatment, yield about 82 per cent of bullion, which is approximately 700 fine.

The Cyanide Plant of the Spearfish Gold Mining and Milling Company.

This mill was situated at Cyanide, S. D., in the Ragged Top district and was destroyed by fire during the fall of 1900. The writer made a hasty visit to the plant in the early summer, but had no opportunity to return to it before its destruction. This will account for the meagre details and incompleteness of the description. The plant was a new one, having commenced operations early in 1901. A new plant, practically the duplicate of the old one, except that the tanks are of greater capacity, is in the course of erection. The capacity of the mill was practically 250 tons per day, although only 125 tons per day were treated, as the mine was not in a condition to furnish more, the main difficulty, however, being one of transportation from the mine to the mill, the ore being hauled by wagon to the mill. The distance of the mine from the mill is 800 to 1000 yards. In the new plant there will be a tramway, the cars being hauled by locomotive.

THE NATURE OF THE ORE TREATED.—The ore is a siliceous limestone, occurring as a flat deposit in the Carboniferous, on and near the surface, and is mined very cheaply by open cut, at a cost of about 80 cents per ton. The values seem to occur on the cleavage planes of the limestone, associated with manganese in the form of dendrites. Only coarse crushing is necessary. In this respect the ore is very similar to the Wasp No. 2 ore. The ore varies considerably in value, the average grade having a value of about \$5 to \$7 per ton, although ore as high as \$27 to \$30 and above is found in bunches. The material treated so far is all thoroughly oxydized.

THE CRUSHING OF THE ORE.—The ore goes from the storage bins over a grizzly 6 feet long and 4 feet wide, having $1\frac{1}{4}$ inch spaces. The fines go directly to the rolls, while the coarse material goes to the Blake crusher, which has a 10x20 inch jaw opening. The 125 tons of ore run through the mill were generally crushed in 10 hours. From the Blake crusher the ore goes to the rolls, a set of Davies rolls, 36 inches in diameter and 16 inch face,



CYANIDE MILL OF THE SPEARFISH G. M. & M. CO., PRESTON, S. D.

making 84 revolutions per minute. The ore is then passed over a 2 mesh inclined stationary screen to the finished product bin, the oversize being returned to the rolls. It was found later that better results could be obtained by somewhat finer crushing, and a second set of rolls were put in, with the suitable screen alterations.

THE LEACHING DEPARTMENT OF THE MILL.—There are two standardizing tanks, of red cedar, 20 feet deep and 10 feet in diameter, one for weak solution and one for strong solution. The leaching vats are 10 in number, of red cedar, and are 24 feet in diameter and 7 feet deep. They have a 10 inch circular bottom discharge gate, for sluicing out the tailings. The vats are charged by cars running on suspended tracks over the vats, the time consumed in charging being ten hours. The vats have a capacity of 125 tons. There are 2 gold solution storage tanks, 18 feet in diameter and 10 feet deep, and 2 sump tanks, 16 feet in diameter and 10 feet deep.

Precipitation was carried on by zinc thread in the usual form of extractor boxes. There are four of these boxes, 2 for weak and 2 for strong solutions. The boxes have 8 compartments each, 24x21 inches in cross section, with a depth of zinc of 18 inches.

The cyanide practice was practically the same as that described for other similar plants.

The Tailings Cyanide Plant of the Homestake Company.

This is the largest cyanide plant in the Hills, having a daily capacity of 1200 tons of tailings. The mill was built during the latter half of 1900 and the early part of 1901, going into commission about April, 1901. It has been in continuous operation since that date, doing very satisfactory work. The cyanide plant treats the tailings pulp from three mills, the Golden Star, the Highland and the Eighty mills, crushing roughly about 2000 tons of ore per day. The information regarding the working of the mill is meagre and incomplete, the policy of the Homestake Company not permitting of the disclosure of information concerning the technical working of their plant.

THE TRANSPORTATION OF THE PULP FROM THE STAMP MILLS.

—The pulp is carried from the mills to the cyanide plant in a 10 inch cast iron pipe, supported above ground. On its way to the mill the pulp is taken through the classifier house, about 1-5 of a mile from the cyanide mill, where it passes through cone slime separators (described below), which eliminate some of the slimes, the main portion of the pulp going on to the mill.

THE SEPARATION OF THE SANDS FROM THE SLIMES. —The material as it comes from the plates is very fine, a considerable percentage passing a 200 mesh screen. The object of the preliminary treatment is to take out only as much of the slimes as is necessary, and leave a product that is leachable. The first separation is made in the classifier house, mentioned above, by means of 8 hydraulic classifiers. These are of a flat, cone shape, about 4 feet in diameter and 3 feet deep (approximate), made of sheet iron. No upward water current is employed, the heavier sands settling out, while the finer material overflows at the periphery, where it is caught in an annular launder. The pulp is fed by a pipe at the center of the classifier, the flow being regulated by a valve. The apex of the cone ends in a two way discharge cock, also regulated by a valve. This affords a continuous discharge for the sands, making the apparatus automatic. The partly classified pulp discharged from these separators goes by a 10 inch pipe to the cyanide plant, where it is taken by 7 more of

these classifiers, still more slimes being separated out. The settlings from this set of classifiers are fed continuously to a series of 4 compartment jigs, one classifier feeding 4 jigs. The jigs are of the Harz pattern, 4 compartments, the first 3 compartments having relatively coarse screens, while the last one has a fine screen. Jigging is done on a bed of pyritous concentrates. The last compartment is widened out to accommodate the increased amount of discharge water. The stroke of the plunger varies from about $\frac{1}{8}$ inch in the last compartment to almost $\frac{1}{2}$ inch in the first. The sands are continuously discharged through the hutch gates of each compartment, and go by launder to the pipe distributors, which charge the vats. The overflow from the last compartment of the jig is discarded, as well as the overflow from the cone classifiers. Lime is added, in the form of an emulsion (made by a special mixing apparatus), to the launders, which carry the jig sands to the pipe distributors.

The distributors, which fill the leaching vats and make the final separation of sands and slimes, are of the Butters type, having pipe arms of different lengths so as to cover the whole surface of the vat. There is one distributor for each row of seven vats, the distributor being transferred from one vat to another, as occasion requires, on an overhead track, and fastened in each case to the rod which operates the central bottom discharge gate of each vat. The vats are placed on very secure foundations, to insure their being practically level, still further provision for having a perfectly uniform overflow being made by grooving the top of the staves and inserting a $\frac{1}{2}$ inch pine tongue, projecting $\frac{1}{2}$ to $\frac{3}{4}$ inch above the top of the staves, entirely around the circumference. This tongue can then be planed in the uneven places until the overflow is uniform all around the periphery. The overflow is caught in an annular launder surrounding the vats, and from here carried off. As already stated, the object is to have as many slimes go with the sands as possible and have a leachable product, and as the classifiers, jigs and distributors can all be adjusted as regards the product they make, this is readily done. While both the slimes and sands carry values, the sands alone are treated at present. The slimes from the classifiers and jigs in the mill, go to a settling vat, the water being used again in sluicing out the leaching vats. The total ore crushed by the stamp mills is in the neighborhood of 2000 tons per day, while the amount of sands treated in the cyanide mill is 1200 tons per day. This means an elimination of about 800 tons of ma-

terial as slimes, or about 40 per cent, which is at present not treated.

THE NATURE AND VALUE OF THE MATERIAL TREATED.—The ore crushed consists mainly of quartz and hornblende, carrying varying amounts of sulphides up to 7 per cent, mainly pyrite and some pyrrhotite, and free gold. The value of the tailings pulp is about \$1.50 per ton, the sands treated by cyaniding having approximately the same value.

THE LEACHING DEPARTMENT OF THE MILL.—The leaching vats are 14 in number, placed in two rows of 7 each. They are built of California redwood, and are 45 feet in diameter and 9 feet deep, holding about 700 tons of sands. They have one central bottom discharge gate and four side discharge gates. The sands are leached directly in the filling vats.

THE PRECIPITATING DEPARTMENT OF THE MILL.—Precipitation is carried on by means of zinc dust in 5 tanks, of redwood, 2 inch staves, 25 feet in diameter and 20 feet deep. The bottom of the tank inclines to a small sump, in order that the tanks may be completely drained. The tanks are emptied by duplex Prescott pumps, which transfer the precipitates and solution to filter presses, made in the Homestake shops. The solution in the tanks, after the addition of the zinc dust, is agitated by compressed air, the plan of operation being similar to that described for the Wasp No. 2 mill.

No information is available concerning clean-up facilities and further treatment of precipitates.

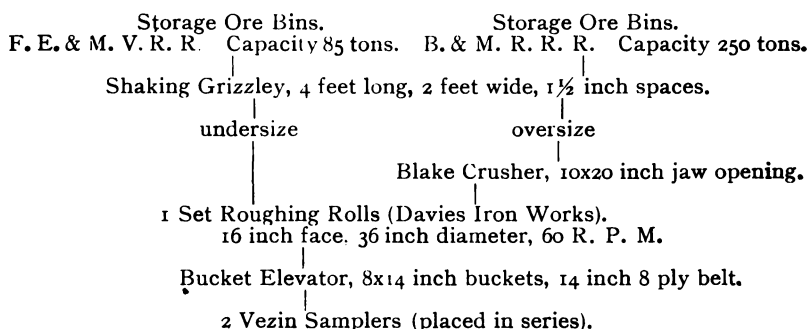
COST OF CYANIDING AND PERCENTAGE OF EXTRACTION.—The last annual report of the Homestake company gives the cyanide expenses at 28 cents, figured on the total tonnage. The cost of cyaniding, per ton of sands treated, is close to 50 cents per ton. The extraction made is said to be in the neighborhood of 90 per cent, a very high result, considering the nature of the material treated.

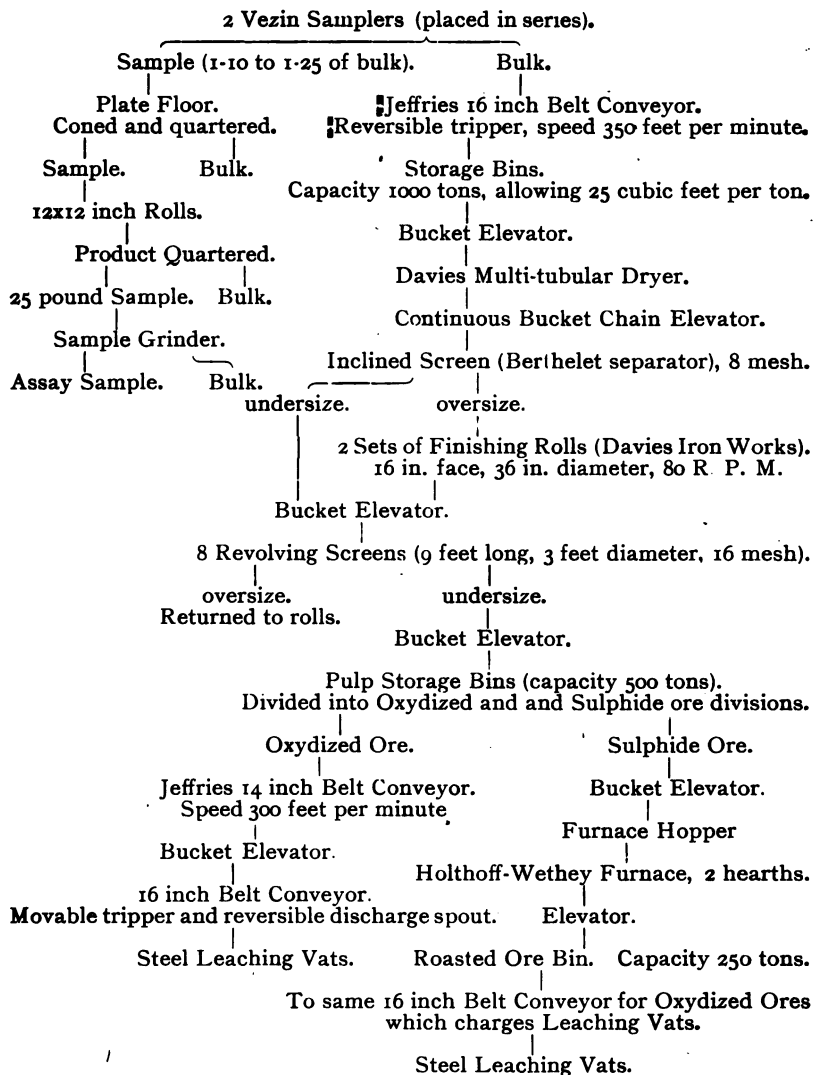
The Cyanide Plant of the Imperial Mining and Milling Company.

This is a new plant in course of erection in the First ward of Deadwood, a short distance from the Dakota plant, already described. It is a dry crushing plant, with roasting facilities for the heavier "blue" ores, and will have a capacity of 100 tons per day, with provisions to increase to 250 tons in time. The power plant being installed is sufficient for the latter capacity. The plan of the mill follows the Colorado pattern at Florence, treating telluride ores from the Cripple Creek district. It is built entirely on level ground, the crushing, roasting and leaching departments being in separate, but closely adjoining buildings, the transference of pulp being accomplished by elevators and belt conveyors. The whole plant is built very substantially on solid concrete foundations. The buildings are all iron clad.

The mill represents a different type from that to be found in the Black Hills, and as it is to treat ores of the same nature that the Dakota and Portland mills are treating, in fact from properties in close vicinity to the mines of the latter mills, a comparison can be made between the two methods of treatment, which will be of considerable interest, as regards the relative merits of fine dry or fine wet crushing with the slimes treatment of the latter method. As the mill is designed to treat custom ores, 2 Vezin samplers, placed in series, are being installed, with the necessary sample crushing plant to further reduce the sample cut out by the samplers.

SCHEME OF TREATMENT AT THE IMPERIAL CYANIDE PLANT.—





THE CRUSHING MACHINERY.—A shaking grizzly, 4 feet long by 2 feet wide, takes out the fines, while the coarse ore goes to a 10x20 Blake crusher. The ore is further crushed by one set of Davies rolls, 16 inch face and 36 inches in diameter, with Latrobe steel shells. The rolls make 60 revolutions per minute. The crushed ore then goes through the Vezin samplers, after which the bulk of the ore is dried in a Davies multi-tubular dryer (a revolving cylindrical drying furnace), and then goes to 2 sets of

finishing rolls, after being screened over an 8 mesh inclined screen. Each finishing roll, with its following 4 revolving screens and elevators, is constructed as a unit, so that one set of rolls can be run independently of the other. The advantage of this is evident in case of a breakdown in the crushing machinery. The finishing rolls are of the Davies type, 36 inches in diameter and 16 inch face, having a speed of 80 revolutions per minute. It is seen that the roughing rolls and finishing rolls are of the same size, permitting of change of the roll shells, from the finishing to the roughing rolls, when the first become too uneven for uniform crushing.

All the rolls and screens are steel housed, and these housings are connected by two Sturtevant exhaust fans, with 2 Prinz and Rau dust collectors, consisting of a revolving spindle, on which are stretched collecting bags. The dust is drawn in at the center of the spindle and collected in the bags, from which in turn it is discharged, by automatically shaking the bags, the collected dust being carried by a conveyor to the pulp bins and mixed with the pulp. In this way no dust is accumulated for separate treatment, but what is formed is treated with the pulp.

The pulp storage bin is divided into two divisions of 250 tons each, one for sulphide ores and one for the oxydized ores, these being kept separate throughout their course through the mill, the sulphide ore going from the bins to the roasting furnace.

THE ROASTING FURNACE—This is a Holthoff-Wethey two hearth furnace, the upper hearth being the roasting hearth, while the lower one acts as a cooling hearth. The inside dimensions of the hearth are 121 feet length and 12 feet width. The outside dimensions are, length 131 feet, width 14 feet. By the time the ore gets to the lower end of the cooling hearth it is cool enough to be taken by the elevator and raised to the bins. The ores to be roasted are light in sulphur.

THE LEACHING DEPARTMENT OF THE MILL.—There are 4 steel leaching vats, 35 feet in diameter and 6 feet deep, the body being of 3-16 inch steel and the bottom of $\frac{1}{4}$ inch steel. The vats hold 200 tons and have 5 bottom discharge gates, loperated from above. There are also 4 smaller leaching vats, placed so as to utilize the waste room left by the large vats, due to their circular shape. These are 10 feet in diameter and 6 feet deep, holding 16 tons. There are 2 gold solution storage tanks, 16 feet in diameter and 4 feet deep, and 2 sump tanks, 20 feet in diameter and 4 feet deep, and 2 solution storage tanks, 20 feet in di-

ameter and 4 feet deep, all of steel, same size of material as the leaching vats. Precipitation will be carried on by zinc thread in steel precipitation boxes. The sulphuric acid method will be used to refine the precipitates. The leaching vats will be connected with vacuum chambers, to facilitate the final washing of the pulp.

THE POWER PLANT.—There are 2 Heine water tube boilers, of 125 horse power each, to carry 150 to 200 pounds of steam pressure. The engine is a 250 horse power tandem compound Hamilton Corliss, non-condensing. There is an electric light plant of 250 lights. The power plant is large enough for a 250 ton mill, and it is intended to eventually install 2 more sets of finishing rolls, with their screens and elevators, and 4 more 35 foot leaching vats.

The Cyanide Plant of the Golden Reward Mining and Milling Company.

This is a new mill in the course of erection in Deadwood, on the site of the Golden Reward chlorination plant, destroyed by fire some years back. The capacity of the mill is to be 200 tons per day. The mill is to treat oxydized siliceous ores, mostly from the Portland and Ruby Basin districts, the nature of which has already been described in several instances. The mill is to crush fine by rolls, and with the Imperial plant will afford a comparison as regards the relative merits of the dry fine crushing and wet crushing and slimes treatment as carried out by the Dakota and Portland mills.

THE CRUSHING OF THE ORE —The ore, after it passes over the grizzly, will go to a No. 3 gyratory Gates crusher, from which it goes to a cylindrical revolving drying furnace, 22 feet long and 5 feet in diameter. From the drying furnace the ore passes to 2 No. 2 Gates gyratory crushers, and from these to 5 sets of Krom rolls, arranged as roughing and finishing rolls. These rolls are all 26 inches in diameter and 15 inch face. Stationary inclined screens are suitably interposed, the finished product to be 20 mesh and finer. There are to be no roasting furnaces.

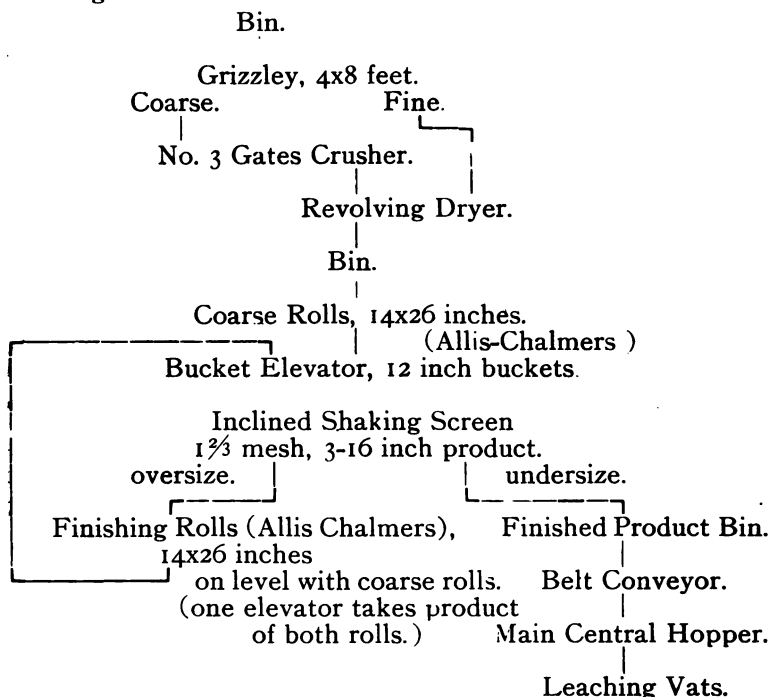
THE LEACHING AND PRECIPITATION DEPARTMENTS. —There are 12 leaching vats, 35 feet in diameter and 5 feet deep, each having a capacity of 150 tons of ore. The vats are of California red cedar.

Zinc shavings are to be used in precipitation. It is said that the mill is to use an electro-cyanide process.

The Cyanide Plant of the Alder Creek Gold Mining Company.

This plant is situated near Kirk, about 700 feet northeast of the Wasp No. 2 cyanide mill, already described. The mill is at present in the course of erection and will be completed about March, 1902. The mill is to treat ores very similar to what the Wasp No. 2 is treating, and the general plan of the mill is the same, except for the arrangement of the leaching vats. The capacity of the mill is 50 to 60 tons per day.

THE CRUSHING OF THE ORE.--The following is the scheme of crushing.



THE LEACHING DEPARTMENT OF THE MILL.—There are 4 leaching vats, 16 feet in diameter and 8 feet deep, placed in nest, that is, the four tanks occupy a square space. They are charged by means of a flexible spout 16 feet long, which issues from a hopper placed centrally above the 4 leaching vats. This hopper

is fed from the finished product bin by a 14 inch belt conveyor.

Above the leaching vats are 2 storage solution tanks, 10 feet in diameter and 10 feet deep. The sump and gold storage solution tanks are situated below the leaching vats, and are all 10 feet in diameter and 6 feet deep. All tanks are of red cedar.

Precipitation will be carried on in barrels, similar to the plan described for the Wasp cyanide mill, except that the solution will be carried to the bottom of the barrel by pipe, instead of a specially constructed compartment on the side, which is often very difficult to make tight enough, so as to prevent leakage of the solution and consequent imperfect precipitation. The main advantage claimed for the barrels is that they are separate units, which can be handled easily in the clean up.

The Tailings Plant of Allen Bros. & Soule at Carbonate, S. D.

This is a temporary summer plant, not enclosed, which treated the tailings from the old silver amalgamation mill of the Iron Hill Company at Carbonate, S. D. The capacity of the plant was somewhat irregular, due to the varying leaching qualities of the tailings, but when working at its best treated about 35 tons per day. The plant being an open one, the weather also interfered somewhat with its working.

THE NATURE OF THE TAILINGS TREATED.—The tailings are siliceous, containing from 8 to 13 ounces of silver per ton, and only about .01 ounce in gold. The average value in silver is about 10 ounces. Three and one-half to four per cent of lead is present, mostly in the form of lead carbonate, also small amounts of antimony, arsenic and mercury, and very small amounts of copper. The last two constituents are artificial contents, having been added during the silver milling. The tailings have been exposed to oxydation for a number of years.

THE LEACHING FACILITIES OF THE PLANT.—There are 6 leaching vats, 14 feet in diameter and 5 feet deep, also 2 solution tanks 10 feet in diameter and 10 feet deep, and the necessary sump tanks, all of wood. The leaching vats are bridged over so that the filling can be done by scraper. The precipitation is carried on in zinc boxes. A pump, operated by steam, is employed to transfer the solutions.

THE CYANIDING OF THE TAILINGS.—Instead of adding potassium cyanide to the tailings in the vat in the form of the usual solution, it was added in the solid form by mixing it with the tailings in the vats and then running on water, or solution. The advantage of this method over the usual one is not stated. The strength of the solution was determined as it leached from the vats, and varied from 7 to 8 pounds per ton, down to $\frac{3}{4}$ or $\frac{1}{2}$ pound per ton, according to the length of time the ore had been leaching.

The consumption of cyanide was quite constant, amounting to 1.6 pounds per ton of tailings. The amount of cyanide mixed

with the tailings in the vats depended on the amount of cyanide the sump solutions carried, these being used over again.

The first solution which leached from the vats usually carried from 10 to 16 ounces of silver per ton. This gradually decreased, until the last solutions coming off were not considered sufficiently valuable to handle, when they were replaced by wash water, and after this was off, the tailings were discharged by sluicing.

After impregnating the tailings with solution, this was allowed to stand 3 hours before commencing leaching, then the solutions were circulated continuously until the tank was discharged.

The total time of treatment is not given

The tailings showed no soluble or latent acidity, but 1 pound of lime was added per ton, and was found to reduce the consumption of cyanide.

PRECIPITATION.—Precipitation was carried on in zinc boxes by zinc shavings, and was found to work very well. The precipitation was nearly perfect, even when the cyanide contents of the solution were very low (.025 per cent). The precipitation of silver from cyanide solutions by zinc shavings offers several phenomena, which seem to differ from the precipitation of gold under the same conditions. It was noted that the precipitation was almost completed in the first compartment of the zinc box. While with gold solutions this is true to a great extent, it is not as pronounced as in this case with the silver solutions.

The greater part of the time there seemed to be no apparent action in the extractor boxes, as is indicated in the precipitation of gold solutions by the evolution of hydrogen bubbles.

Much of the time when high grade silver solutions were passing through the boxes the outgoing solution at the foot of the boxes would show more cyanide than when it entered at the head, pointing to a regeneration of cyanide, or cyanide in such a form as to react like free potassium cyanide with silver nitrate. No definite figures are available to show the actual increase. There was an extraordinarily low consumption of zinc, 14½ ounces troy of silver bullion being obtained for every pound of zinc put into the extractor boxes. This is very remarkable, and differs decidedly from the experience in gold cyaniding. The zinc consumption per ounce of bullion produced at the Wasp No. 2 is 0.9 *pound*. Here at the silver tailings mill it is 0.83 *ounce* per ounce of bullion produced, or stated per ton less than ½ pound.

The precipitates obtained contained about 30 per cent silver and 10 per cent of mercury.

The extraction made on the tailings was about 60 per cent of the silver value, which is very close to the results obtained by laboratory tests. The balance of the values are carried in such form as not to be attacked by potassium cyanide.

THE COST OF CYANIDING.—The cost of cyaniding these tailings is stated to be about \$2.50 per ton, varying, however, between \$2 or \$3, dependent on the daily capacity, which, owing to the exigencies above mentioned, varied considerably.

The Cyanide Plant of the Cleopatra Gold Mining Company.

This mill is situated on Squaw creek, about one mile from Carbonate, S. D. It has a capacity of 40 tons per 24 hours. The mill is of the usual dry crushing type already described, the ore treated being siliceous Cambrian ore, requiring only coarse crushing to liberate the values. The mill is one of the first of the larger mills of the district to demonstrate the success of the cyanide process when applied to the siliceous ores, and to its success the further application of the process in the district may be partly ascribed. It began operations in August, 1900.

THE NATURE OF THE ORE TREATED.—The ore is a sandstone, nearly a quartzite, occurring near the top of the Cambrian, most of the ore treated being well oxydized. Coarse crushing is sufficient to liberate the values, the ore in this respect being very similar to the ore of the Wasp No. 2 mine and the Spearfish ore. Just how the values are distributed has not been definitely determined. It is, however, likely that their occurrence is similar to that at the Spearfish mine, where the gold seems to occur along certain cleavage planes, which become the planes of fracture in crushing.

THE CRUSHING OF THE ORE.—The mill is a typical hillside plant, full advantage being taken of gravity for the transference of the ores. The ore goes from the bins to a No. 3 Gates gyratory crusher, from thence over a 2 mesh screen (4 openings per square inch). What passes through the screen is finished product, while that which passes over goes to the roughing rolls, 1 set, 30 inches in diameter and 14 inches face, having a speed of 80 revolutions per minute. The crushed ore from the roughing rolls again goes over a 2 mesh screen, what goes through being finished product, while that which passes over goes to the finishing rolls, 24 inches in diameter and 14 inch face, making 100 revolutions per minute. The product from the second set of rolls goes to the finished product bin directly, without screening. The final product is $\frac{1}{4}$ inch and less in size.

THE CYANIDING OF THE ORE.—There are 6 leaching vats, 18

feet in diameter and 6 feet deep, each holding 40 tons of ore. The vats are charged by means of a belt conveyor, from the finished product bin, and discharged through two 12 inch bottom discharge gates into the cars beneath the vats. Slacked lime is added at the upper bin, usually about 5 pounds per ton of ore being required to keep the solutions at the required alkalinity. The protective alkalinity carried is equivalent to 1.2 to 2.4 c. c. of N-10 sodium hydrate per 10 cubic centimeters of solution. This is equal to 0.86 to 1.72 pounds of lime per ton of solution. (See method of determining protective alkalinity in Part II.)

When the vats have been filled with crushed ore, 12.6 tons of strong solution, containing 4 pounds of potassium cyanide per ton, are run on and allowed to stand on the ore for 60 hours. This solution is then drained through the zinc boxes, and when practically all off the ore 10 tons of sump solution, usually having a strength of 3.7 pounds cyanide, is pumped on, continuously, percolating through the ore to the zinc boxes. Then 10 tons more of sump solution are pumped on, and when this has just disappeared below the surface 4 tons of wash water are added, completing the leaching. The total time required for leaching is about 108 hours, which does not include time of charging or discharging. The total time required for a vat of ore from filling to filling is between 5 and 6 days. Precipitation is carried on by zinc thread in the usual form of zinc boxes, and is very complete, the tailings solution usually assaying but a trace in gold. The solutions passing through the boxes rarely carry less than 2.8 pound of cyanide per ton. The value of the first strong solution passing to the zinc boxes is generally about \$4.55 per ton.

The table below is interesting, as it shows the consumption of cyanide in the zinc boxes and the increase in alkalinity of the solution. While the titrations were made with only the usual care employed in practical working, and not with regard to ascertaining any scientific data, they may still be considered valid evidence on the mooted question as to what takes place in the zinc boxes under given conditions.

RECORD OF ZINC BOX A.

TIME.	Head Solutions.			Tail Solutions.		
	KCN. Pounds per Ton.	Protective Alkalinity, No. of c. c. N-10 NaOH per 10 c. c. of Solution.	Au. in Ounces per Ton.	KCN. Pounds per Ton.	Protective Alkalinity, No. of c. c. N-10 NaOH per 10 c. c. of Solution.	Au. in Ounces per Ton.
June 11—Day.....	3.4	1.4 c. c.	0.22	2.3	2.6 c. c.	Trace
June 11—Night.	3.0	1.4	0.13	2.5	2.1	Trace
June 12—Day... ..	2.8	1.6	0.08	2.2	2.1	Trace
June 12—Night.....	2.9	1.7	0.04	2.0	2.5	Trace

SAMPLING OF THE ORE AND SOLUTIONS.—The crushed ore is sampled during the filling in the leaching vats by levelling of the charge at intervals, and taking a hand sample, these combined samples are cut down and the final sample represents a vatful of ore. The tailings are sampled by taking grab samples from the tailings cars as they are run to the dump. The solutions are sampled at the heads and ends of the zinc boxes by drip samples as mentioned under the description of the Golden Gate mill.

COST OF CYANIDING.—The cost of cyaniding is about 80 to 85 cents per ton, the following being the incomplete detail of the cost:

	Per Cent.
Fuel.....	\$0.10
Mill labor	0.413
Lime.....	0.0375
Oil and extras.....	0.025
Cyanide.....	0.180
Total.....	\$0.7555

This detailed list does not include cost of zinc or repairs, or interest and depreciation. Not including the last two items, the cost of zinc and repairs may be estimated from the Wasp No. 2 mill, where very similar conditions exist. There the cost of zinc is 0.031c and repairs 0.086c, which would bring the cost to about 86c per ton, which is certainly very low for a plant of this capacity.

The cyanide consumption is about 0.6 pound per ton of ore.

No figures are available as regards the average value of the ore and the extraction.

The Cyanide Mill of the Shawmut Mining Company.

This mill is also known as the Esmeralda mill, and is situated in Blacktail Gulch, about one-half mile from Central. The mill is not at present in operation, but it is rumored that it will start again during the year. The plant, during the latter part of 1900 and early part of 1901, treated "cement" ores successfully by combined amalgamation and cyaniding. The capacity was 30 tons per day.

THE CRUSHING AND AMALGAMATION OF THE ORES.—The ores are from the lowest series of the Potsdam, known locally as "cement ores," in which a considerable portion of the gold is in a form that can be amalgamated, differing in this particular from the Potsdam siliceous ores, already often mentioned.

The ores rest on the Algonkian, which in this particular case were in part amphibole schists, so that often the ores contained considerable of this rock, causing the formation of much very fine slimes, particularly as the ores were crushed by a Huntingdon mill.

The ore was crushed rough in a Gates crusher and then fed to the five foot Huntingdon mill, which discharged the pulp to a revolving amalgamator, which in turn fed it to about 8 feet of copper plates.

THE CYANIDING OF THE ORES.—The pulp from the plates was elevated by a spiral sand pump to a central launder, which discharged, as desired, into one of three separator boxes, one of which was placed above each of the three sand leaching vats. These separator boxes have already been described for the Dakota and Portland mills. The boxes in this case were built in two compartments, each 24x30 inches in cross section and 3½ feet deep. The time consumed in charging the vats by these means is two days.

The leaching vats for sands are 3 in number, built of Oregon fir, and are 16 feet in diameter and 5 feet deep. The sands were leached, after being drained, by a 5 pound cyanide solution, followed as is usual in the district, by a weak solution and wash water. The value of the sands averaged about \$5 to \$6 per ton.

There are 4 slimes vats, of the same dimensions as the sand vats, two of the slimes vats being used as settling vats.

The slimes overflow from the separator boxes was taken to either No. 1 or No. 2 of the slimes settling vats, which were provided with overflow gates near the top, the overflow from No. 1 vat going into No. 2 for a short time after No. 1 is filled. When filled the slimes were allowed to settle and the water was syphoned off. Then strong cyanide solution, about 5 pounds per ton, was added, and the resultant mixture was transferred by centrifugal pump to slimes vat No. 3, where the slimes were settled and the solution syphoned off and drawn to the extractor boxes.

Weak solution, from the zinc sump, was then added, and the mixture pumped by the centrifugal pump to the fourth slimes vat, where the slimes were settled and the solution syphoned off. The settled slimes were then discharged by sluicing, no wash water being applied, mainly for the reason that tankage was lacking, and the slimes must be discharged in order to make room for the next lot. The value of the slimes was stated to be from \$1.50 to \$2 per ton, sometimes as low as \$1.20 per ton. This last figure is said to have just about paid for the cost of the slimes treatment. Lime is used in settling the slimes, being added in the launder issuing from the separator boxes. Precipitation was carried on by zinc thread in two boxes, one for weak and one for strong solution.

The mill is interesting, from the fact that it treated the "cement ores," and is also the only mill in the district to employ amalgamation and cyaniding, and treat by cyaniding both the sands and the slimes resulting from the crushing.

It was one of the mills in the district to first apply the wet crushing process on a fairly large scale, being at the time of its operation in charge of Mr. John Hinton, who was the first one to apply the wet crushing method and work out its details for the Black Hills ores. The Shawmut mill, as described, was of necessity more or less of an experimental plant, and by no means perfect in its appointments, especially those pertaining to the slimes treatment were crude and insufficient.

The Clevenger Tailings Plant.*

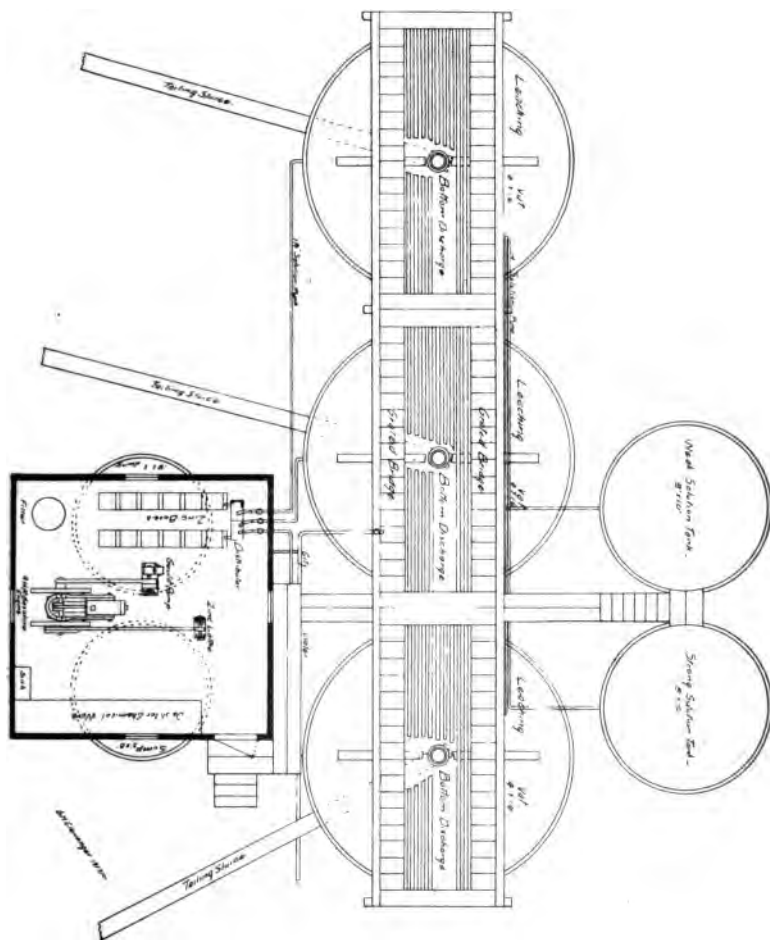
This plant was a summer plant, situated at Rapid City, S. D., and treated the accumulated tailings from the chlorination mill, whose operations had proven a failure some years back. The cyanide plant was in operation during the fall of 1900 and the spring and summer of 1901, when the tailings were exhausted and the plant removed. The tailings originated from the siliceous ore of the Northern Hills (Gilt Edge mine), which had been shipped down to the chlorination plant for treatment. The value of the tailings varied considerably, the bulk ranging from \$4 to \$6 in gold and about 1 ounce in silver. The three leaching vats were bridged over by a grated bridge (made of scantlings, 2x6 inches, with 2 inch spaces between them), and were charged by means of a wheel scraper and team, in from 4 to 5 hours. Later on, as the available tailings had to be hauled a longer distance, the time consumed in charging was lengthened to 8 and 9 hours. The capacity of the plant was 30 tons per day.

THE TANK ARRANGEMENT OF THE PLANT.—There were 3 leaching vats, built of pine, 16 feet in diameter and 4 feet deep, provided with one central bottom discharge gate. There were also 2 solution tanks, 10 feet in diameter and 8 feet deep, and 2 sump tanks, 8 feet in diameter and 3 feet deep. The plant was situated on a hill side, the solution tanks above and the sump tanks below the level of the leaching vats. The leaching vats were discharged by sluicing, the time required being from 2 to 3 hours, dependent on the water pressure from the city mains, which varied.

THE CYANIDING OF THE TAILINGS.—In charging the vats with tailings, slacked lime was added at intervals to the extent of 4 to 5 pounds per ton. Strong cyanide solution, containing 3 pounds of cyanide per ton, was run into the vats simultaneously with the charging of the tailings, making a considerable saving in time. When the vat had been filled the solution was started draining,

*The writer is indebted for much of this information to Mr. G. H. Clevenger, and to an article, "Clevenger's Cyanide Plant," by Mr. A. Overpeck in the School of Mines "Aurum" for January, 1902.

being replaced by fresh strong solution. This circulation of strong solution was carried on for 30 hours, when weak solution, containing from 1.4 pound to 2 pounds per ton, was circulated for about 20 hours, this being finally replaced by wash water, which was allowed to run through for 12 hours. The total time



of treatment from filling to filling was 72 hours. The amount of solution used was 30 to 40 tons per vat. The extraction made was relatively low, only about 50 to 60 per cent of the gold value being recovered. The balance of the value could not be extracted, even finer crushing failing to liberate the values.

The solutions were pumped from the sumps to the solution

tanks by a Gould rotary pump, operated from a 4 horse power Fairbanks-Morse gasoline engine, which also furnished the power for the zinc lathe.

THE PRECIPITATION OF THE GOLD CYANIDE SOLUTIONS.—Precipitation was carried on by means of zinc thread in sheet iron precipitation boxes. There were six of these boxes for the strong solution and the same number for the weak solution. The boxes were of similar design to the ordinary extractor box, and each held one cubic foot of zinc shavings. The last box in each series was not filled with zinc, in order to settle any particles that were carried over. The boxes proved very efficient, and were conveniently handled in the clean-up, which was made once in three weeks.

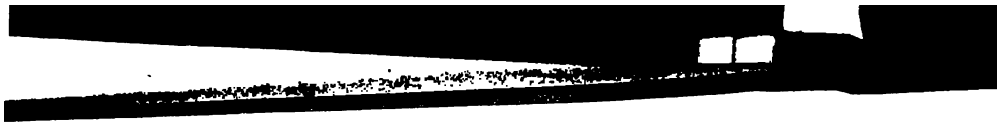
The precipitation was very good, no trouble of any kind being experienced. The precipitates contained about equal weights of gold and silver.

THE TREATMENT OF THE PRECIPITATES.—The coarse zinc was separated as far as possible from the precipitates, which were then transferred to the filter tank, a small cylindrical tank, having in it a filter of 3 thicknesses of heavy canton flannel, the chamber below the filter being connected with a large water aspirator, such as is used in chemical laboratories. The precipitates were thoroughly washed, and then transferred to large wooden tubs and treated to dilute sulphuric acid. When the action had ceased the precipitates were allowed to settle and the solution drained off by a series of one inch holes in the side of the tub. Stronger acid was then added, and after standing was diluted considerably. The precipitates and solution were then again transferred to the filter tank, the solution filtered off and the precipitates thoroughly washed to remove zinc sulphate. The precipitates were finally put into sheet iron pans and dried in a large iron muffle, the heat being finally raised to a dull red. The precipitates were then mixed with the usual fluxes and smelted in graphite pots.

The cost of cyaniding the tailings was about \$0.85 to \$0.90 per ton.

PART II.

General.



A List of the Cyanide Plants in the Black Hills.

No.	Name of Mill.	Location.	Capacity. Tons per Day.
I. PLANTS IN OPERATION.			
1	Homestake Tailings Plant.....	Lead, S. D.....	1300
2	Portland Cyanide Plant.....	Gayville, S. D.....	60
3	Wasp No. 2 Cyanide Plant.....	Near Kirk, S. D.....	105
4	Dakota Company's Cyanide Plant..	Deadwood, S. D.....	60
5	Cleopatra Mining Company's Cyanide Plant.....	Squaw Creek, S. D....	40
6	Deadwood Standard Cyanide Plant	Near Preston, S. D....	200
7	Highland Chief Cyanide Plant....	Spruce Gulch, S. D..	50
2. PLANTS NOT IN OPERATION (These are mostly old and small experimental plants.)			
1	Golden Gate Cyanide Plant*....	Deadwood, S. D.....	65
2	Shawmut Mining Company's Cyanide Plant.....	Blacktail Gulch S. D..	30
3	Detroit & Deadwood Company's Cyanide Plant.....	Anne iCreek, S. D....	60
4	Deadbroke Mining Company's Cyanide Plant.....	Blacktail Gulch, S. D	Small
5	Dakota Mining Company's Cyanide Plant (old).....	Central, S. D.....	Small
6	Clevenger Tailings Plant†.....	Rapid City, S. D.....	30
7	Allen Bros. Tailings Plant (summer plant).....	Carbonate, S. D.....	35
8	Holloran Cyanide Plant.....	Lead, S. D.....	25
9	Mystic Cyanide Plant (secret electric process).....	Mystic, S. D.....	100
10	Holy Terror Cyanide Plant‡.....	Keystone, S. D.....	
3. PLANTS IN COURSE OF ERECTION.			
1	Homestake Tailings Plant.....	Gayville, S. D.....	700
2	Spearfish Mining and Milling Company's Cyanide Plant¶.....	Cyanide, S. D.....	250
3	Imperial Mining and Milling Company's Cyanide Plant.....	Deadwood, S. D.....	100
4	Golden Reward Cyanide Plant....	Deadwhod, S. D.....	200
5	Alder Creek Mining Company's Cyanide Plant.....	Near Kirk, S. D.....	60

†Tailings exhausted. ‡Experimental plant for arsenical concentrates.

*To be remodeled and again begin operations. ¶On the active list before its destruction by fire.

Historical.

The first cyanide plant erected in the Black Hills was the mill of the Black Hills Gold and Silver Extraction Company,* built in 1892, with a capacity of about 30 tons per day. This plant is described in a somewhat remodeled condition as the Golden Gate mill in this paper. The mill has not been in continuous operation since its construction, and its workings have been rather desultory. In 1896 it treated but 6500 tons of oxidized Potsdam ores, while its capacity was 11,000 tons per year. It seems that previous to the erection of this mill the Portland Mining company had tried experimentally to cyanide ores from the Bald Mountain district, but had failed. The Golden Reward chlorination mill had a cyanide annex to treat ores containing considerable silver, over 3 ounces, which would have been lost in chlorination. The process was carried on in revolving barrels similar to those used in chlorination.

The prospects for the cyanide process, even as late as 1896, were not very bright, and chlorination seemed to be the process of the future, the Golden Reward and Kildonia mills treating 75,000 tons of ore, against the 6,500 tons treated by cyaniding.

Nothing new developed in the matter of cyaniding ores during 1897, except, perhaps, the contemplation or erection of tailings plants along Whitewood creek. In August, 1898, the Shannon plant, a small tailings plant on Whitewood creek, was said to be in operation. In August, 1898, an old mill at Spearfish, S. D., was remodeled as a cyanide plant, and commenced treating ore in October, 1898. Its capacity was about 20 tons per day, the ore coming from Calamity Gulch, in the Ragged Top district. The plant was later enlarged to a greater capacity, and continued to be in operation steadily for some time, until destroyed by fire in July, 1900.

Another small plant, known as the Alexander plant, started operations at Garden City in November, 1898. This was also an old mill remodeled as a cyanide plant. The plant was never continuously in operation for any length of time.

*T. A. I. M. E., Vol. 27. 1897. Prof. F. C. Smith.

The success of the Deadwood and Spearfish plants stimulated the activity for the application of the process considerably during 1899. The Deadbroke Mining Company in Blacktail Gulch, R. M. Maloney manager, installed the cyanide process in connection with plate amalgamation in July, 1899, treating cement ores. The plant has, however, never been in continuous operation, the cause of which, however, does not seem due to inapplicability of the process. In June, 1899, the Homestake Company started its 30 to 40 ton experimental plant at Lead, on the tailings from its stamp mills. The outgrowth of these experiments is the new 1300 ton tailings plant.

In July, 1899, the small plant of Allen, Small & Co. (known as the Long Valley plant) began operations in Calamity Gulch, south of Ragged Top, and was in successful operation for some time.

The old Wilson stamp mill at Central City was also remodeled by Mr. J. Hinton and Mr. S. Bullock as a cyanide plant during the latter part of 1899, and has been in operation off and on to the present time, serving mainly as an experimental plant.

In December, 1899, the Hildebrand stamp mill at Gayville was remodeled as a cyanide plant by Messrs. Parker, Gibbs and Cook, and treated cement ores. The method of working at the Deadbroke mill, treating the pulp from the plates, led to the direct crushing of the ores in the battery with cyanide solution in the Gayville and Central City mills. This seems to be the inception of wet crushing with cyanide solution in the Black Hills.

The method was first used in 1897 by the Crown Mines Company in New Zealand, under the direction of Mr. F. R. W. Daw.* Mr. John Hinton is entitled to the credit of adapting and perfecting the process for the Black Hills ores.

During 1900 much progress was made, most of the mills now running beginning operations in that year. About June, James Holloran began operating a small plant, 25 tons capacity, at the Golden Crown mine in the North Lead district. In August the 40 ton plant of the Cleopatra Mining Company, on Squaw Creek, started operations, as well as the Dakota & Deadwood Company's Annie Creek plant, and in September the 60 ton plant of the Wasp No. 2 Mining Company, on Yellow Greek, was put into commission. Somewhat later in the year the Shawmut Mining Company (not now running), in Blacktail Gulch, and the Port-

*Cyaniding in New Zealand. T. A. I. M. E. Vol. 29. 1899. James Park-

land Mining Company, at Gayville, started their wet crushing plants.

The year 1901 saw still further progress. In the very early part of the year the cyanide plant of the Spearfish Gold Mining and Milling Company, at Cyanide, began operations. In April the large tailings plant of the Homestake Company began treating the tailings from the stamp mills, and in October the wet crushing plant of the Dakota Mining Company went into commission.

During the year the Kildonia chlorination plant at Pluma suspended operations, leaving no chlorination mill at work in the Hills. The outlook for 1902 is very promising. Five large mills are in the course of construction and a number of others are planned, some of which will undoubtedly materialize in the course of the year.

The tonnage treated by the cyanide process in the Black Hills in 1901 amounted to about 88,000 tons of ore and 280,000 tons of tailings, a total of 368,000 tons. This will be greatly increased during the present year.

The Nature of the Ores Treated by the Cyanide Process in the Black Hills.

The ores treated at the different mills have already been shortly described under the description of each individual mill. From a geological standpoint three kinds of ore are treated.

1. Ores from the Algonkian—Lead, the Homestake vein.
2. Ores from the Cambrian—Portland, Ruby Basin, Bald Mountain district, etc.
3. Ores from the Carboniferous—Ragged Top, etc.

ALGONKIAN ORES.—The ores from the Algonkian are quartzose in the main, the gold in part being free in quartz and also in finely disseminated pyrite throughout the schistose rocks. The schistose rocks comprise mica and amphibole schists, argillites, etc. The sulphide found is mostly pyrites, though some arsenopyrite and pyrrhotite is also present. The percentage of sulphurets is about 3 to 6 per cent. The average value of these ores is in the neighborhood of \$4 per ton, of which the unoxidized ores yield approximately \$2.50 to amalgamation, leaving \$1.50 per ton in the tailings which are cyanided.

CAMBRIAN ORES.—*Cement Ores.*—The quartzite conglomerate, which lies directly on the Algonkian, furnishes the so-called "cement ores." In these the gold is free in part and is found in the material cementing the pebbles of the conglomerate. These ores are not at present of great economic importance. They have been cyanided with somewhat varying success at the smaller mills about Central City, the Deadbroke, the Shawmut and the Parker, Gibbs & Cook mills.

The Cambrian Siliceous Ores.—These are known locally as the Potsdam siliceous ores, and occur most generally as a siliceous replacement of some of the lower layers of lime shales, which rest on the quartzite corresponding to the Potsdam of the Cambrian.

However, these siliceous ores often occur as verticals and at higher horizons in the Cambrian, to a smaller extent. The ores are divided locally into "red ores," which are oxidized, and "blue ores," which are unaltered. So far the ores which have

been treated in the cyanide plants have been oxydized ores in the main.

In the unaltered ore considerable fine grained pyrite is found, which has been changed into iron oxydes in the red ores, giving the characteristic red appearance. The unaltered ores have a distinct blue gray cast. The amount of pyrite varies within considerable limits, the maximum being 15 to 20 per cent, and the average about 6 to 8 per cent. Some of the ores contain much less.

The average percentage of silica for the Potsdam ores is stated to be 78 per cent by Dr. F. R. Carpenter. It is higher than this in the oxydized ore, about 84 per cent, while in the blue ores it is lower, about 69 per cent. This is due to the loss in iron and sulphur in oxydation, raising the silica percentage.* About 3 to 4 per cent of alumina is also present in the ores.

There is but little free gold present in the ores, and even in the oxydized ores comparatively little shows. That which is present is very rusty, and but a small percentage of it is amal-

Prof. F. C. Smith, cited above, states† that tellurium is of frequent occurrence in the Potsdam ores, and states that the gold is probably in combination with it, although the actual tellurium mineral has not been isolated and examined.

If tellurium does occur in the ores generally, and it certainly occurs in some, no attention has been paid to it so far in the metallurgical treatment of the ore.

All of the siliceous ore is very hard. While some classes, however, are very dense, there are varieties of both the blue and red ore which are fairly porous. To this condition may be ascribed the fact that some of the mills can crush as coarse as they do and still attain a very good percentage of extraction. The fact is often mentioned that in some cases, as at the Wasp No. 2, the gold is carried on certain planes of the ore, which become the planes of fracture in crushing, thus liberating the values even with coarse crushing. While this may be so, it has never been actually demonstrated. If it be so the condition is similar to that which occurs at the Spearfish Company's mines in the Ragged Top district. Here the ores occur in the Carboniferous

*F. C. Smith. T. A. I. M. E. Vol. 27. 1897. "The Potsdam Gold Ores of the Black Hills."

†F. C. Smith. T. A. I. M. M. Vol. 26. 1896. "Occurrences and Behavior of Tellurium in Gold Ores."

and contain considerable lime and less silica. At Mercur, Utah, similar conditions exist, as described by Mr. G. A. Packard.* He says: "The ore is somewhat porous and the value occurs largely along certain lines of cleavage, which become the lines of fracture, enabling the ore to be treated with only a very coarse crushing."

In many of the Potsdam ores, however, the gold occurs in such a way that only fine crushing liberates the values.

Antimony, in the form of stibnite, is found in small quantities in the ore of the Wasp No. 2 mine, as well as sometimes a small amount of galena. Copper is also found in very small quantities in some of the Potsdam ores. The value of the Potsdam ore range within wide limits; \$4 ore has been treated profitably; \$8 to \$10 ore exists in large quantities, and much higher grades are also constantly being mined.

THE CARBONIFEROUS ORES. - These ores occur in several types of deposits, one of which, the Ragged Top verticals, are siliceous replacements of limestone, existing as vertical veins of limited depth and width within the limestone. The ores, in physical and chemical characteristics are a counterpart of the Potsdam ores.

Another type is represented by the ore body of the Spearfish Mining Company, situated at Cyanide. The ore here seems to occur in a nearly flat deposit of siliceous limestone, certain zones of which have been impregnated with the values. The ores occur very near the surface, in fact, at the outcrop no stripping of any moment had to be done. The siliceous limestone is overlain by a limestone proper, which near the contact also carries values. The gold values are seemingly carried on the cleavage planes of the limestone, and are associated in a great measure with manganese in the form of dendrites.

While the ore is siliceous, the lime contents are considerable, differing in this way from the Potsdam ores.

Coarse crushing suffices to liberate the values and permit of their extraction by cyanide solution.

The value of the Carboniferous ores, like the Potsdam ores, varies within considerable limits. There are, however, in the last deposit large quantities of \$7 to \$8 ore.

*G. A. Packard. T. A. I. M. E. Vol. 26. 1896. "The Cyanide Process in the United States."

The Cost of Cyaniding.

Wherever it was possible to obtain detailed costs, these are stated under the descriptions of the mills. The following is a table of the costs at the various plants:

Name of Mill.	Method in Use.	Remarks.	Tons Treated per Day.	Total Cost per Ton.
Spearfish Plant	Dry coarse crushing.	{	125	\$0.80
Cleopatra Plant..	Dry coarse crushing.	{	40	0.86
Wasp No. 2 Plant	Dry coarse crushing.	{	105	0.83
Golden Gate Mill.	Dry fine crushing.	{	65	3.95-4.10
Portland Mill.....	Wet crushing and slimes treatment.	{	60-65	1.75-2.00*
Dakota Mill.....	Wet crushing and slimes treatment.	{	60	1.50-1.75*
Clevenger Plant....	.....	Cyaniding chlorination tailings. }	30	0.85-0.90
Allen Bros. & Soule..	.....	Cyaniding silver mill tailings. }	35	2.50
Homestake Plant....	.....	Cyaniding stamp mill tailings. }	1300	0.50*

*Figures with a star are not official, but are estimates, which, however, closely approach the actual cost.

It will be noticed that the cost at the mills treating coarse crushing ores is about the same, 85 cents per ton. This cost will undoubtedly be somewhat reduced at the plants of larger capacity, as certain improvements with that end in view are contemplated. Most of the figures given do not include interest on plant, insurance or general office expenses. These added to the

cost per ton will make it somewhat higher. The cost at the Golden Gate mill will be seen to be disproportionately high, in fact, by referring back to the description of that mill, the cost sheet gives the figure above \$5 for some months. This high cost is due to the limited quantity of ore treated, the high rent, and the fact that the mill is old and poorly arranged, necessitating high repair cost and high labor cost. A modern mill, arranged for dry fine crushing, with a capacity of 100 to 150 tons of ore per day, should be able to treat oxydized ores from \$1.25 to \$1.50 and ores which have to be roasted for \$1.90 to \$2.25. The cost of roasting should not be high, as the blue ores are light in sulphur, averaging perhaps 8 per cent.

No detailed figures are available for the wet crushing mills, the total cost varying between \$1.50 to \$2 per ton. This figure is obtained by mills having a comparatively small capacity (60 tons), and in a larger mill, this cost could probably be reduced to in the neighborhood of \$1.25 per ton.

Analysis of Cyanide Mills Solutions from Black Hills Cyanide Plants.

BY G. H. CLEVINGER, B. S.

Amounts are stated as percentages, i. e., as grams per 100 c. c.

Number.	1.	2.	3.	4.	5.	6.
Name of Mill and Kind of Solution.	Clevenger Plant Strong Solution.	Clevenger Plant Weak Solution.	Golden Gate Strong Solution.	Golden Gate Weak Solution.	Wasp No. 2, Strong Solution.	Wasp No. 2, Weak Solution.
Time used.....	6 weeks	6 weeks	3 months	3 months	14 months	14 months
Number of tons of material treated.....	1270	1270	4300	4300	14,000	14,000
Mesh per linear inch.....	10	10	20	20	6	6
Nature of material treated.....	Chlorination tailings.	Chlorination tailings.	Oxydized siliceous & lime ore.	Oxydized siliceous & lime ore.	Oxydized siliceous ore	Oxydized siliceous ore
Nominal working strength { KCN .	0.1	0.05	0.30	0.15	0.25	0.10
{ CN .	0.04	0.02	0.12	0.06	0.10	0.04
Cyanogen in KCN and K ₂ Zn Cy ₄			0.37	0.27	0.38	0.19
Zinc.....	0.0528	0.04307	0.11845	0.116501	0.07832	0.06167
Copper.....			0.00287	0.002164		
Calcium.....	0.0929	0.0613	0.0964	0.1141	0.1269	0.1085
Iron.....	0.0034	0.0016	0.00014	0.000125	0.0001	0.0001
Silica.....			0.0008	0.0005	0.001	0.001
Antimony.....					Trace	Trace
Gold in oz. per ton.....			Trace	0.0125	0.115	0.016
Iron in terms of (K ₄ Fe Cy ₆).....	0.0223	0.0105	0.0092	0.00821	0.0065	0.0065
Thiocyanate.....	0.0		0.10735		0.01511	
Sulphate (K ₂ SO ₄).....	0.2667	0.	0.01009	0.004484	0.002465	0.000822
Residue on evaporation.....			0.681	0.5568	0.5478	0.3380
Residue on ignition.....			0.5610	0.4268	0.4794	0.2730
Alkalinity * { Not boiled			83.8 c. c.	71.6 c. c.	87.4 c. c.	57.4 c. c.
Methyl orange { Boiled			93.0	84.8	93.2	61.2
Alkalinity. { Not boiled			30.6	28.4	44.0	28.8
Phenolphthalein { Boiled			66.8	55.2	70.8	43.2

*Alkalinity determined by titrating 100 c. c. of solution by N-10 H₂ SO₄ sol., also by boiling with 100 c. c. N-10 H₂ SO₄ and titrating back with N-10 KOH sol. Alkalinity expressed in number of c. c. of N-10 H₂ SO₄ solution

The Determination of the Protective Alkalinity of Cyanide Solutions.

The protective alkalinity is that alkalinity of the solution due to the alkaline hydrates (NaOH-KOH), the alkaline earth hydrates (mainly Ca(OH)_2), and one-half of the monocarbonates present in solution. Bicarbonates afford no protection against acidity.

This alkalinity protects the potassium cyanide present in solution from destruction by acids and acid salts, which may be present in the ore or tailings, and also gives the solutions their normal alkaline condition, necessary for the best working conditions of the process, in the leaching of the pulp and precipitation of the values.

Alkaline hydrates (KOH) are formed during the leaching, according to Elsner's equation of the solution of gold by potassium cyanide, and also probably during the passage of the gold bearing solutions through the zinc extractor boxes, although the last fact is disputed by some authorities. Alkaline hydrate (NaOH) is also added to the solution in some districts in place of lime.

Alkaline earth hydrates (mainly Ca(OH)_2) are added to the ore or tailings in the form of caustic or slacked lime (the last to be preferred) in order to afford protective alkalinity.

Monocarbonates get into the solutions mainly in the form of an impurity in the potassium cyanide used.

METHODS OF DETERMINING THE PROTECTIVE ALKALINITY.—The method of determining the protective alkalinity, first advocated by Mr. J. E. Clennel, is as follows: A separate test is made to determine the "total cyanide" in solution, by adding an excess of sodium or potassium hydrate and titrating the solution in the usual way with silver nitrate solution, with potassium iodide as an indicator. The same amount of silver nitrate solution used in this test is then added to 10 c. c. of the cyanide solution, and a few drops of phenolphthalein added as an indicator. The solution is then titrated with N-10 H_2SO_4 or HNO_3 solution, the number of cubic centimeters used indicating the alkalinity.

This method is not correct in the presence of zinc, when, according to Mr. Leonard M. Green,* it is possible to get an apparent acidity by the method.

He suggests the following method as an accurate one: An excess of potassium ferrocyanide is added to the cyanide solution to be titrated, then twice the amount of silver nitrate used to indicate the total cyanide is added, after which a few drops of phenolphthalein are added as an indicator and the solution titrated with decinormal acid. The amount used will indicate the protective alkalinity.

The silver nitrate added precipitates the whole of the cyanide, as silver cyanide, while the zinc is also precipitated in the form of zinc ferro cyanide, both compounds being in such form as to be little acted on by the N-10 acid used. It is often possible to get almost identical results by adding only that quantity of silver nitrate as shown by the "total cyanide" test, but in this case there is some danger present of some of the potassium silver cyanide in solution being acted on by the acid, giving erroneous results.

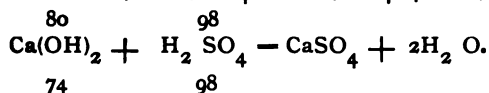
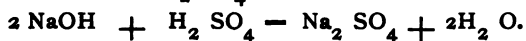
If it is thought that the precipitates of zinc ferro cyanide and silver cyanide may be acted on by the acid (of which, however, there is little danger), these can be filtered from the solution before the titration with the N-10 acid.

In some of the mills of the district it is customary to determine the protective alkalinity by adding a few drops of potassium ferro cyanide, then titrating for free potassium cyanide with silver nitrate solution, then adding a few drops of phenolphthalein as an indicator, and titrating for alkalinity with N-10 sulphuric acid solution. This method will not give correct results, for the reasons already stated.

The protective alkalinity is very often stated quantitatively in terms of N-10 sulphuric acid. As in most cases 10 c. c. of potassium cyanide solution are used for titration, this is readily stated in terms of slacked lime per ton of solution by the following calculation:

*"A Method of Testing Cyanide Solutions Containing Zinc," by L. M. Green, in the Transactions of the Institution of Mining and Metallurgy reproduced in the Mining Reporter of Denver for January 16 and 23, 1902.

1 c. c. of N-10 H_2SO_4 = 1 c. c. of N-10 NaOH = 0.004 grams NaOH.



$\frac{74}{80}$ or 0.925 parts of Ca(OH)_2 = 1 part NaOH = .0037 grams Ca(OH)_2

hence for every cubic centimeter of N-10 sulphuric acid used, there is present 0.0037 grms. of calcium hydrate.

Then $\frac{.0037}{10} \times 100 = 0.037$ per cent of calcium hydrate present in the solution

for every cubic centimeter of N-10 sulphuric acid used in the titration.

Then $20 \times .037 \times \text{No. of cubic centimeters of N-10 sulphuric acid used}$, will give the number of pounds of slacked lime dissolved in a ton of the solution.

This figure also includes the sodium or potassium hydrates and the monocarbonates, these being stated as lime, but in this district, where lime is almost exclusively used, the amount of sodium and potassium hydrates is comparatively small, as well as the monocarbonates.

Notes on the Assay of the Zincy Precipitates Obtained in the Cyanide Process.

BY CHARLES H. FULTON AND CHARLES H. CRAWFORD.

The work described in the following pages was performed with the object of establishing a satisfactory method of assay for the zincy precipitates obtained in the cyanide process, endeavoring to evolve a method at once accurate and short, which can be used in an ordinary custom assay office or mill. The difficulty of satisfactorily and correctly assaying rich material containing much zinc, had been frequently noticed, and in view of the fact that the cyanide process is of widely increasing importance, and that the smaller plants but rarely possess arrangements for the refining of the precipitates, but dispose of them according to their assay value, a method giving rapid and accurate results would be of value

The precipitates used in the work were obtained from a 30 ton cyanide plant, using the Mac-Arthur-Forest cyanide process on roasted chlorination tailings. The material was typical, containing 42.3 per cent zinc in a finely divided state (some of it present as oxide), 23.2 per cent SiO_2 (insol. residue), small quantities of Ca, Mg, Al, traces of Mn, Cu, Sb, and about 2,320 ounces of gold and 2,869 ounces of silver per ton.

The sample used in the assays was obtained as follows: About thirty-five pounds of the dried precipitates were thoroughly mixed on a large oil cloth, then spread until the mass had a uniform thickness of one-half inch. It was then marked off into 2-inch squares by a sharp spatula. All told there were about 250 2-inch squares. From each square a small amount was then dipped, care being taken to go down to the bottom in each case, and to take the same quantity from each square.

The amount thus taken, about one-fourth pound, was put into a glass-stoppered bottle. It is very difficult to get a uniform sample of material of this kind, so further care was bestowed on the preparation of the one-fourth pound taken out. The sample was put through a 100 mesh sieve, and as but very little metallic zinc remained on the screen, this was also forced through. The sample was then

thoroughly mixed for a long time. In taking out the amount used for an assay the procedure was as follows: The whole sample was spread out thin, divided into a large number of squares, and about one-half to three-fourth assay tons sampled out. This amount was then again spread out, divided into squares, and the one-twentieth or one-tenth assay ton for the assay sampled out from this. This was repeated for every charge weighed out. All weighing was done on an analytical balance.

SCORIFICATION METHOD.—Scorification was the first method tried, all the precautions recommended in the scorification assay of zincy ores being observed, such as a large proportion of lead to ore and low heat during scorification. The amount of precipitates taken was one-twentieth assay ton. See Table I. Charges number one and two and five and six were run with seventy grams of test lead and one gram of borax glass. Charges three and four were run with seventy grams of test lead and one gram of borax glass, and fifteen grams of litharge as a cover. In every case the precipitates were mixed with half the lead, placed in the bottom of the scorifier, and covered with the rest of the lead.

The slags and cupels were assayed in the usual way.

Referring to Table I, it will be seen that the results are abnormally low when compared to the other methods. The slag corrections are very high. The slags obtained from the assay of the first slags undoubtedly still carried considerable values, but in referring to the corrections obtained from the crucible slags, in the same table, it can be seen that even if these corrections were made, the total result would be much too low. This points to an excessive loss by volatilization in the scorification method. The method was discarded as unsatisfactory.

CRUCIBLE METHOD.—The second method tried was the crucible method, with the following charge: 1 10 a. t. precipitates, 1½ a. t. litharge, 1½ a. t. soda, ½ a. t. borax glass, 5 grams fluorspar, 2 grams argol.

The charge was made basic so as to get a stony slag from which the button would separate, easily and cleanly. Table I, assays I and II, show the result. The slag corrections are not high and results also indicate volatilization.

The following charge was then used, recommended by Wm. Magenau, E. M.:*

*Mining and Scientific Press, April 28, 1900.

TABLE I.—SCORIFICATION AND CRUCIBLE ASSAYS.

Number of Assay.	Crucible.	Crucible.	Uncorrected Assay.		Corrected Assay.		Amount Re-covered from Slag.		Amount Re-covered from Cupel.		Percentage of Value in Uncorrected Assay.		Percentage of Value in the Slag.		Percentage of Value in the Cupel.		Ratio of Silver to Gold in Corrected Assay.	Uncorrected Assay, Total		Corrected Assay, Total
			In Ounces per Ton.		In Ounces per Ton.		In Ounces per Ton.		In Ounces per Ton.		of Value in the Slag.		of Value in the Cupel.		Gold and Silver.					
			Gold	Silver	Gold	Silver	Gold	Silver	Gold	Silver	Gold	Silver	Gold	Silver	Au	Ag				
1	{	Crucible.	1403.0	1898.1	2006.8	2647.2	582.0	637.00	21.8	112.20	60	66	25	22.	0.93	3.9	.757	3301.1	4654.0	
2			1426.0	1994.4	1972.4	2591.0	540.0	557.80	6.0	38.80	61	69	23	19.0	0.26	1.3	.761	3420.8	4563.4	
3			1375.6	2025.2	1884.1	2427.2	504.0	362.00	4.5	40.00	55	71	22	13.0	0.19	1.4	.766	3400.8	4311.3	
4			1456.2	2062.6	1827.0	2473.6	366.2	370.4	4.6	40.60	63	72	16	13.0	0.19	1.4	.738	3518.8	4300.6	
5			1372.6	1968.6	1891.4	2479.2	516.8	500.80	2.0	9.80	59	68	22	17.0	0.08	0.34	.762	3341.2	4370.6	
6	{	Crucible.	1213.2	1963.2	1895.2	2711.8	680.0	770.6	2.0	18.0	52	68	29	26.0	0.085	0.66	.698	3176.4	4607.0	
7			2028.7	2416.6	2054.2	2478.1	22.6	28.1	2.9	33.4	87	84	0.97	0.98	0.12	1.10	.828	4445.3	4532.3	
8			2032.4	2462.2	2043.8	2503.1	9.1	14.5	2.25	26.3	87	86	0.39	0.51	0.10	0.91	.816	4494.6	4546.8	
9			2303.1	2762.1	2353.8	2867.3	46.8	62.2	3.90	43.0	99	96	2.0	2.1	0.17	1.50	.821	5065.2	5221.1	
10			2321.3	2808.9	2348.8	2876.4	18.0	24.2	6.50	43.3	99	98	0.77	0.84	0.28	1.50	.817	5133.2	5225.2	
11	{	Crucible.	2186.1	2613.9	2253.0	2727.3	63.7	76.2	3.20	37.2	93	91	2.7	2.6	0.13	1.30	.826	4800.0	4977.4	
12			2284.1	2760.8	2319.6	2851.1	31.8	45.5	3.70	44.8	94	96	1.3	1.6	0.16	1.50	.813	5044.9	5138.9	
13			2339.5	2784.0	2355.7	2859.75	0.8*	6.3	15.40*	69.45	100	96	0.03	0.20	0.66	2.40	.823	5123.50	5215.45	
14			2312.8	2761.2	2329.1	2833.5	0.6*	14.3	15.70*	58.00	95	96	0.02	0.40	0.67	2.10	.822	5074.0	5162.6	

*Abnormal, omitted in calculation of averages.

1-10 assay ton precipitates, 70 grams litharge, 5 grams sodium carbonate (dry), 1 gram flour, 5 grams silica, 2 grams borax glass.

The results obtained by this charge are good, but are apt to vary. Compare Table I, assays A, B, C, D, E, F. As will be seen by comparing Table III, this method gives the highest average result (corrected), on gold, but not the highest on silver. The uncorrected results are higher in the combination methods. The loss in the slag is very variable, being very small in one case and running up to a considerable value in other cases. While the method in many cases gives the highest result, it will again give a low result without any apparent reason, the conditions as regards charge and heat being in all cases the same.

COMBINATION METHOD.—The next method tried was the combination wet and dry assay, using nitric acid. 1-10 a. t. of precipitates were treated with 20 c. c. conc. nitric acid and 60 c. c. of water. This was boiled gently for one hour, cooled and diluted to 100 c. c. with water. Then 75 c. c. normal salt solution (5.4207 grams NaCl to the liter) were added, also 5 c. c. conc H_2SO_4 and 20 c. c. of lead acetate solution. The precipitate was allowed to settle for an hour and a half, filtered and washed to the point of the filter paper, dried and burned at a heat just high enough to ignite paper, and then scorified with 40 grams test lead. Buttons were cupelled in usual way. Table II, assays U, V, K and M, will show the results obtained. The gold is far below that shown in crucible assays, even the corrected results. The silver is higher than in the crucible assays. This pointed so directly to the fact that gold passed into solution that tests were made to demonstrate this. The filtrates from assays No. K and M, having been carefully preserved, were treated as follows: They were evaporated nearly to dryness, expelling all of the nitric and nitrous acids, then were diluted to 100 c. c., adding 2 c. c. of conc. sulphuric acid and 10 c. c. of lead acetate solution. Sulphuretted hydrogen was then passed through the solution for one-half hour. Some of the lead sulphate was changed to lead sulphide, the whole of the precipitate settling to the bottom readily. It was then filtered out, washed and treated in the same way as already described under the combination nitric acid method. The beads obtained were [seemingly all gold and weighed 596.4 and 568.2 mgs., calculated to the assay ton. The above is the weight after parting, almost identically the same as

TABLE II. ---COMBINATION METHODS.

Method Used and Number of Assay.	Uncorrected Assay. In Ounces per Ton.		Corrected Assay. In Ounces per Ton.		Uncorrected Assay, Total Gold and Silver.	Corrected Assay, Total Gold and Silver.	Amount Recovered from Slag, In Ounces per Ton.		Amount Recovered from Cupel, In Ounces per Ton.		Percentage of Value in Uncorrected Assay.		Percentage of Value in the Slags.		Percentage of Value in Cupel.		Gold Recovered from Filtrate. In Ounces per Ton.	Ratio of Gold to Silver.
	Uncorrected Assay.		Corrected Assay.				Amount Recovered.		Amount Recovered.		Percentage of Value.		Percentage of Value.		Percentage of Value.			
	Gold	Silver	Gold	Silver			Gold	Silver	Gold	Silver	Gold	Silver	Gold	Silver	Gold	Silver		
Sulphuric.	1	2361.6	2833.4	3266.0	2888.6	5195.0	5254.6	17.7	2.50	37.40	101	99	0.038	0.62	0.10	1.3	0.819	
	2	2362.6	2826.7	3236.5	2870.3	5189.3	5236.8	16.0	1.90	27.60	101	98	0.043	0.56	0.081	0.96	0.824	
	3	2320.0	2815.3	3234.5	2865.4	5135.3	5189.9	7.9	3.50	42.20	99	98	0.045	0.27	0.19	1.4	Trace	
	4	2278.9	2847.7	3228.6	2899.3	5126.0	5186.1	12.3	3.20	39.30	97	99	0.20	0.43	0.13	1.3	Trace	
	5	2284.6	2846.4	3287.8	2886.0	5131.0	5173.8	11.2	2.10	28.40	98	99	0.047	0.39	0.09	0.99	0.792	
Sulph. Nitric.	6	2310.0	2825.3	3217.2	2870.3	5135.3	5187.5	4.30	2.95	40.5	99	98	0.18	0.16	0.13	1.4	0.807	
	7	2316.2	2776.8	3231.0	2824.3	5093.9	5145.36	11.6	2.69	35.9	99	97	0.093	0.40	0.11	1.2	0.821	
	8	2288.4	2803.3	3229.3	2828.0	5091.7	5144.06	17.1	2.69	35.9	99	98	0.093	0.40	0.11	1.2	0.804	
	a	920.0	2779.1	925.75	2819.35	3699.1	3745.10	3.00	2.75	34.25	39	97	0.12	0.41	0.12	1.2	.....	
	b	1765.5	2814.8	1768.15	2819.70	4580.3	4587.50	9.80	.....	.....	75	98	0.11	0.34	.....	.....	.....	
Nitric.	U	2063.5	2836.1	2066.1	2874.8	4899.2	4940.9	0.40	2.20	29.30	88	98	0.017	0.33	0.094	1.0	.....	
	V	215.4	2846.2	2156.7	2886.5	5001.2	5043.2	0.30	2.00	33.30	92	99	0.013	0.24	0.086	1.2	.....	
	K	1778.4	2805.0	3227.95	2839.4	4583.4	5167.35	0.70	1.95	25.0	76	97	0.034	0.33	0.083	0.87	546.9	
	M	1704.0	2772.8	2282.70	2815.5	4476.8	5098.2	8.80	1.70	29.8	73	96	0.38	0.46	0.073	0.10	568.2	

before parting, the only difference being that due to the silver in the test lead.

The fact that gold goes into solution when treated with nitric acid, under certain conditions, is well known.* It has been shown that this is due to the formation of nitrous acid† during the treatment, which readily acts on the gold. The conditions were very favorable for the action in this case, the gold being present in considerable quantity and in an extremely fine state of division. Whether the presence of finely divided zinc, more so than another base metal acted on by nitric acid, increases the formation of nitrous acid, and in this way the greater solution of the gold, the authors do not pretend to determine.

By adding the amounts obtained from the filtrates the results in gold are brought up nearly to the average corrected assays of the other methods. (See Table II.)

In order to overcome the difficulty of the gold going into solution by the formation of nitrous acid, the fourth method, combination wet and dry assay, using sulphuric acid, was tried. The method of procedure was as follows: 1-10 a. t. of precipitates was treated with 20 c. c. concentrated sulphuric acid and 60 c. c. of water. This was boiled for one hour, then filtered, washed and dried. Care was taken to wash the precipitate into the point of the filter. The paper was burned off at a very low heat, and the residues scorified until half covered over in the scorifier, then poured and the button cupelled. Thirty to forty grams of lead were used. Table II, assay 1 to 8 inclusive, will show the result. As regards the gradual decrease in value, as shown in the column "corrected assay-total gold and silver," reference will be made later on in this paper.

The results are good and quite uniform, as uniform as can be expected with material of this kind. The gold is lower than in the crucible assay, while the silver is higher. The slag corrections in this method, as also in the nitric acid method, are small (relatively), as is to be expected. In order to see whether any gold passed into the solution the filtrates from assays 3 and 4 were treated as described under the nitric acid method, but only a trace of gold found. Whether the precipitation is complete by the method employed is not known. The fact that the gold (corrected) obtained by the sulphuric acid method is somewhat

*T. K. Rose, *Metallurgy of Gold*, and references, pp. 478, 479.

†W. R. Van Liew's paper *E. and M. J.*, April 21 and April 29, 1900, pp. 498.

TABLE III.—AVERAGES AND CONCLUSIONS.

Method of Assay.	Average Uncorrected Assay. In Ounces per Ton.		Average Corrected Assay. In Ounces per Ton.		Total Gold and Silver. Uncorrected Average.		Total Gold and Silver. Corrected Average.		Average Amount covered from Slag. In Ounces per Ton.		Average Amount covered from Cupel. In Ounces per Ton.		Average Percentage of Value in Uncorrected Assay.		Average Percentage of Value in Slag.		Average Percentage of Value in Cupel.		Ratio of Gold to Silver.	
	Gold	Silver	Gold	Silver	Gold	Silver	Gold	Silver	Gold	Silver	Gold	Silver	Gold	Silver	Gold	Silver	Gold	Silver	Au	Ag
Sulphuric acid . . .	2315.3	2821.9	2320.39	2869.30	5137.1	5188.64	2.17	11.6	2.69	35.9	99.1	98.25	0.40	0.11	1.3	0.808				
Crucible fusion. . .	2291.6	2748.5	2326.6	2835.89	5040.1	5156.77	24.2	33.9	3.74	44.33	96.6	95.5	1.04	0.16	1.5	0.821				
Nitric acid. . .	1893.2	2815.0	var.	2842.54	variable	variable	2.62	10.08	2.12	30.33	.....	97.5	0.11	0.091	1.0	.....				
Scorification.	1774.4	1985.3	1912.8	2555.0	3358.68	4467.81	531.5	533.1	3.80	29.80	58.3	69.0	23.0	0.17	1.0	0.747				

lower than that obtained by the crucible method,[] may point to the fact that some gold goes into solution by the sulphuric acid treatment,* which cannot be recovered by the method used. That it cannot be recovered by sulphuretted hydrogen appears doubtful.]

The fine state of division of the zinc in the precipitate renders it very liable to oxidation. This oxidation of the zinc, causing an increase in weight, will cause changes in the gold and silver values. To test this point, after the first assays were made, the sample was spread out and allowed to remain in the air in a dry place for five days, when the second set of assays were made. It was then again exposed for one week and the third set of assays made. Set No. 1 is represented by sulphuric acid method Nos. 1 and 2. Set No. 2 by sulphuric acid method Nos. 3, 4, 5 and 6, and crucible method Nos. A, B, C and D. Set No. 3 is represented by sulphuric acid method Nos. 7 and 8, and crucible method Nos. E and F. The result is most clearly shown by the sulphuric acid method assay in Table II, column marked "corrected assays-total gold and silver," the averages being as follows: 1st set, 5,245 oz.; 2d set, 5,184.3 oz.; 3d set, 5,144.7 oz.

These facts lead to the conclusion that the sample should be assayed at once after taking, or kept in such a way that it will not oxidize.

COMPARISON OF THE CRUCIBLE AND SULPHURIC ACID METHOD.
—It will be noticed in looking at Table 2, columns "uncorrected assays-total gold and silver," and "corrected assays-total gold and silver," that the results check quite closely for this kind of material, while the gold and silver by themselves in but few cases check even reasonably well. The results must be considered as sets (marked off by bracket) for the reason mentioned on the preceding page. This comparatively close checking of the total sum of gold and silver is not apparent in the crucible assay. The sulphuric acid method seems to give more uniform results than the crucible method, although the gold by the crucible method is higher. The difference is six ounces gold per ton, not great, at least not great enough to warrant the assumption that the crucible method is superior. The crucible method is apt to give erratic results, without any apparent reason (assays C and E, Table II), and to get reliable results more than two assays on a sample are necessary. The sulphuric acid method, on the other hand, will give a reliable result on a duplication.

*T. K. Rose. Metallurgy of Gold, p. 11

The slag absorption in the crucible method is very variable, while that in the combination methods is first much smaller, and second fairly uniform. In fact, for precipitates from a given mill, which do not vary widely, a constant might be established with fair accuracy, or a correction made on one, which could safely be applied to all the assays. This cannot be done in the crucible method.

The cupel absorption is about constant in all the methods. Slightly higher in the crucible, probably on account of some zinc still retained in the lead bottom.

CONCLUSION AND REMARKS.—Regarding the fact that the sum of the gold and silver, found by the sulphuric acid method, checks fairly closely in a given set of assays, while the gold and silver vary considerably, the writers wish to offer the following solution: The tailings from the treatment of which the precipitates were obtained vary considerably in value, particularly does the ratio of gold to silver vary in different lots. Hence the solution containing the gold and silver will also vary in gold and silver contents as it passes through the zinc boxes from day to day. The zinc boxes, which are cleaned up but once a fortnight, would then contain a precipitate, consisting of an infinite number of small particles, many of which are made up of relatively different amounts of gold and silver. These particles are too small to be broken up by passing the ordinary mesh sieve, and pass into the sample unchanged in constitution. By careful mixing the sample may be made to contain a given number of these particles per unit of volume, and if assay were made on units of volume the results of total gold and silver would not necessarily check, as on account of the variable ratio of gold to silver, the weight of the volume would vary; but since the assays are made on a unit of weight, the total weight of the particles is the same in each assay, while the volumes would vary. This would explain why the results check fairly close in the total gold and silver, but not in gold and silver taken alone, as the particles are made up of different amounts of gold and silver. A column has been calcu-

lated in the tables, $\frac{\text{Au}}{\text{Ag}}$ ratio of gold to silver," which shows the

variation in the ratio. It will be seen that the ratio varies in the different methods of assay, as is to be expected. In a given method of assay, however, it would seem as if it should be constant if the above premises are not true.

It is of interest to note that relatively the loss of gold to silver is greatest in the scorification assay, and least in the crucible assay. The difficulty in getting an even sample with cyanide precipitates has been frequently noticed and commented upon; the preceding explanation probably gives the reason. It is also claimed that the solubility of silver and gold by cyanide solution is relatively different at different temperatures.* In plants where the leaching vats are exposed to the varying temperatures of day and night, which differ much in some localities, this fact will have the same effect on the gold and silver contents of the solution as a difference in the values of the ores.

The losses in slags and cupels have been completely worked out, not to present anything new, but to add to the literature of the subject. The loss in the cupel is fairly constant, being almost wholly determined by the physical nature of the cupel and the heat of cupellation.

All beads of sufficient size were parted, as in the bullion assay, in the form of cornets.

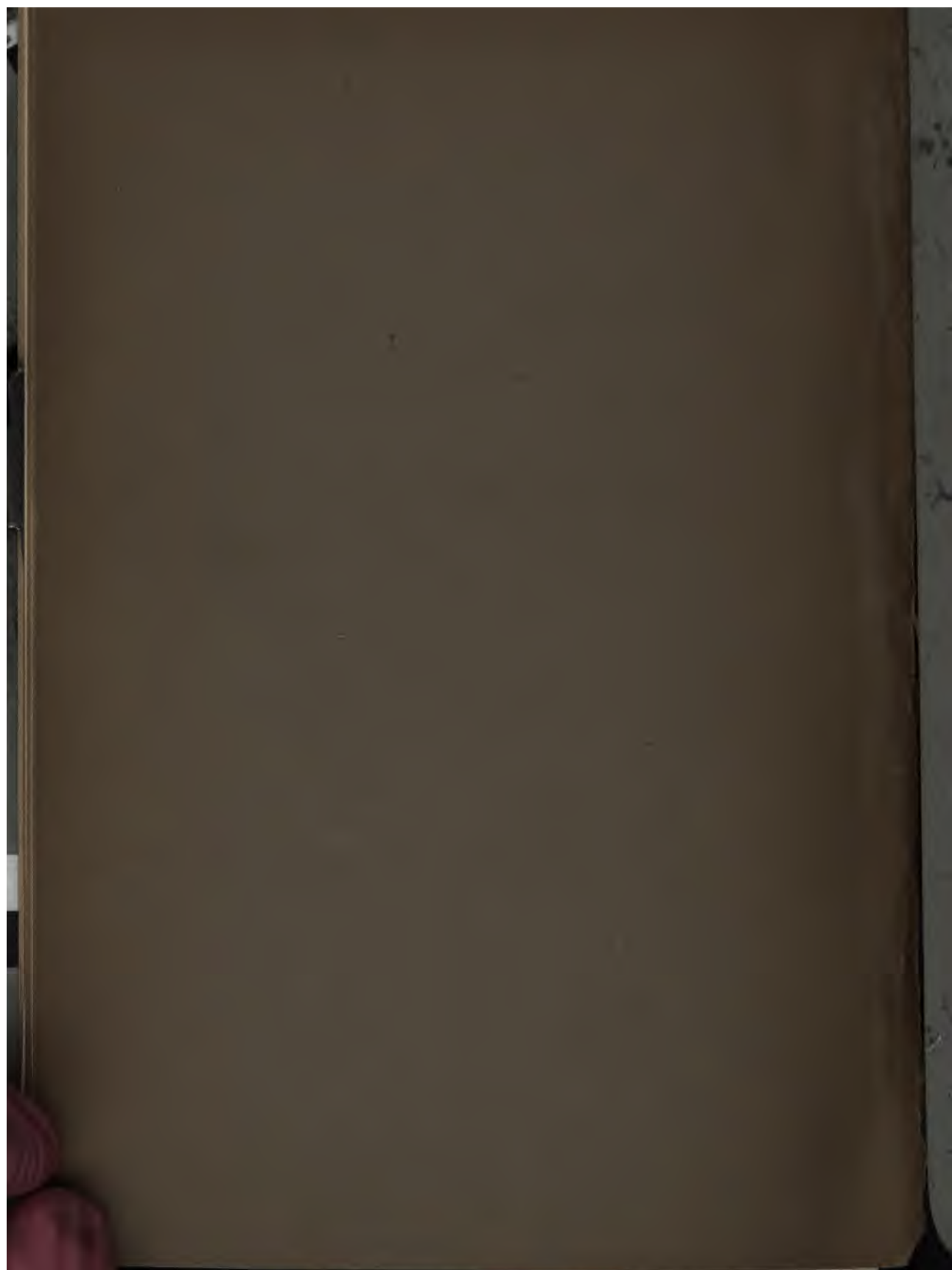
In conclusion, the authors would recommend as the method of assay for the precipitates, either the combination sulphuric acid method or the crucible method, preferably the former. The sulphuric acid method to be performed as described in the preceding pages, using dilute acid 1 to 3 or 1 to 4, and always keeping the acid dilute. Nitric acid, even in small quantities with sulphuric acid is not to be used.† (Also see assays A and B, Table II.)

The slags and cupels are best reassayed and the corrections added; this can be modified as suggested under the combination sulphuric acid method.

Every assay made has been placed in the tables.

*T. K. Rose, "Metallurgy of Gold," p. 357, 1898.

†T. K. Rose, "Metallurgy of Gold," p. 11, 1898.



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U.S. DEPT. OF THE INTERIOR
BUREAU OF MINES
METALLURGICAL PRACTICE

IN THE

BLACK HILLS OF SOUTH DAKOTA.

By CHARLES H. FULTON, M. E.

BULLETIN NO. 7,

OF THE

SOUTH DAKOTA SCHOOL OF MINES.

DEPARTMENT OF METALLURGY.

RAPID CITY, SOUTH DAKOTA.

JUNE, 1904.



BULLETIN NO. 7.

OF THE

ERRATA

1. Page 23, foot note, third line: Read bromine for brome.
2. Page 28, line 30: Read zinc bromide for zinc bromo.
3. Page 28, line 32: Read bromo for bromide.
4. Page 28, foot note: Read Simpson for Sampson.
5. Page 23, line 12: Insert bromo before the word cyanogen.
6. Table III, test No 5, column Time of Treatment: Read "and hours standing" for "48 days standing."
7. Table I, test No. 4, column Time of Treatment: Read "41 hours agitation and 31 days standing" for "60 hours agitation."
8. Table I, test 8, column Time of Treatment: Read "22½ hours agitation for "same."
9. Page 35, first table, Ore C, column "Increase in Extraction," 1st line: Read 6 per cent for 9 per cent.
10. Page 35, second table, in second column heading: Read "31 days contact" for "3 days contact."
11. Page 52 Table, Dakota Mill: Transfer figure "86 tons" in column "amount of solution passing while filling" to column "amount of batte solution."

RAPID CITY, SOUTH DAKOTA.

JUNE, 1904



BULLETIN NO. 7.

OF THE

SOUTH DAKOTA SCHOOL OF MINES

DEPARTMENT OF METALLURGY.

1. Sulphide Smelting at the National Smelter of the Horseshoe Mining Company, Rapid City, South Dakota.

BY CHARLES H. FULTON AND THEODOR KNUTZEN.

2. Laboratory Experiments on the Unoxidized Siliceous Ores of the Black Hills.

BY CHARLES H. FULTON.

3. The Crushing in Cyanide Solution Process as carried on in the Black Hills of South Dakota.

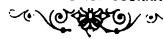
BY CHARLES H. FULTON.

RAPID CITY, SOUTH DAKOTA.

JUNE, 1904



THE RAPID CITY DAILY JOURNAL PRINT.



Letter of Transmittal.

SOUTH DAKOTA SCHOOL OF MINES, }
RAPID CITY, June 5, 1904. }

SIR:—I have the honor to transmit herewith a series of papers, by Charles H. Fulton and Theodor Knutzen, on Metallurgical Processes in South Dakota.

I submit them with the recommendation that they be published as Bulletin No. 7 of the School of Mines.

Respectfully,

ROBERT L. SLAGLE, President.

Hon. Ivan W. Goodner,
President, Regents of Education.

—

Introduction.

The successful treatment of the unoxidized siliceous ores of the Black Hills is a subject of vital interest to the mining fraternity of the region and the experiments on these ores were taken up by the Metallurgical department of the School of Mines with the idea of rendering what assistance it could in this direction to the millmen, knowing that very often their time and opportunity for this kind of work is limited.

The crushing in cyanide solution process has within the last two years assumed great importance in the Black Hills, and for that reason a detailed description of the process should prove of interest.

The writer wishes to express his obligation and thanks to all those who have so kindly and freely furnished him with information; his especial thanks being due to Mr. John Ingersol, Mr. J. V. N. Dorr, Mr. Freeman Steele, Mr. G. Howell Clevenger, Mr. John Cross, Mr. Baldwin, Mr. James Hartgering and Mr. John Millikin.

He wishes also to acknowledge the indebtedness due to Mr. William Bowman, his assistant, for the faithful and careful work done in the experimental tests on the unoxidized ores of the Black Hills, also to acknowledge his indebtedness to Mr. S. S. Arentz for much aid in the same work.



Lundborg, Dorr & Wilson Cyanide Mill, near Terry, South Dakota.



Sulphide-Smelting at the National Smelter of the Horseshoe Mining Co., Rapid City, S. D.*

BY CHARLES H. FULTON AND THEODOR KNUTZEN.

THE plant of the National Smelting Company, a corporation controlled by the Horseshoe Mining Company, was built during 1901 to smelt the dry siliceous ores of the northern Black Hills, extracting the gold and silver values in a matte of low copper-percentage which is shipped to Omaha and Denver for refining. Originally, the plant was designed to collect the values of the siliceous ores in an iron-matte, which was to be resmelted with lead-ores, in a lead furnace, the lead-bullion produced to be refined into Dore bullion in English cupelling-furnaces. However, the scarcity of lead-silver ores in the Black Hills, owing to the present non-productiveness of the Galena district, led to the abandonment of this plan; and both shaft-furnaces of the plant were run as matting-furnaces, the mattes produced being shipped as above stated.

It is not our intention to present anything very new, but rather to supplement the interesting and valuable paper, *Pyritic Smelting in the Black Hills*, by Dr. Franklin R. Carpenter.¹

Smelting in the Black Hills is a difficult matter from a commercial point of view, owing to the fact that the only productive material going into the furnace, generally, is the siliceous ore and a little copper-ore, the pyrite, or pyrrhotite, and the limestone, being barren of values, and no lime-ores, or gold or silver-bearing pyrite being at present available in the Black Hills. The recent price of coke from the east or from Colorado has also been prohibitive (\$9.50 per ton), and Cambria, Wyoming, coke (\$4.50 per ton) is of such inferior quality that it cannot be used alone, but has to be mixed in the proportion of 2 to 1 with

¹ *Trans.*, xxx., 764.

* [Reprinted from the Transactions of American Institute of Mining Engineers February, 1904.]

eastern or Colorado coke, to be able to smelt with it at all.

The National Smelting Plant is situated at the eastern end of Rapid City, on a terrace site on a spur of the Fremont, Elkhorn & Missouri Valley Railroad, a branch of the Chicago & Northwestern Railway system. Directly below the railroad-trestle are nine 125-ton bins: Three for siliceous ore, 2 for limestone, 2 for coke, and 1 for coal. The bottom of the bin slopes 50° , the planking being protected from wear by railroad-iron, placed transversely every foot.

The material is shipped to the smelter in 20-ton ore-cars, usually having a bottom-discharge. It is sampled by shoveling on a sampling-floor at the top of the bins. Lots of 60 tons or less are sampled by taking every fifteenth shovel, while those in excess of 60 tons are sampled by taking every twentieth shovel. The sample is thrown down a chute at the side of each bin, carried by a barrow to the sampling-works, and is there crushed in a 9-by 15-in. Blake crusher which divides it into halves by an "A" discharge, one-half going directly to a pair of 24- by 12-in. Allis-Chalmers rolls. The discharge from these rolls is reshoveled, every fifth shovel being taken as the sample, or every tenth shovel, if the ore lot is more than 60 tons. The sample obtained in this way is crushed in a pair of 12- by 12-in. sample-rolls, then coned and quartered on a plate-floor, and the resultant sample ground in a sample-grinder. The moisture is determined at once on the sample-floor, in a specially provided drying-cup-board.

FURNACES—There are two blast furnaces, one, a copper-matting furnace, 144 by 38 in. in cross section at the tuyeres, and 15 ft. in height to the downtake, and the other, a lead-furnace, 120 by 36 in. in cross-section at the tuyeres, and of the same height as the copper-matting furnace. The lead-furnace is used as a matting-furnace by bricking up the well. Both furnaces have removable hearths placed on trucks, and the off-take at one end just below the feed-floor. They are charged by a specially designed bottom-dump charge-car, running directly over the furnace-top. In our opinion this method of charging is the most desirable one. No trouble from fumes is experienced on the charge-floor. The furnaces, however, could easily be increased 4 ft. in height, which would enable better work to be done in them.

Steam is furnished by two 200-h. p. Stirling water-tube

boilers, with a steam pressure of 125 lb. per square inch. A No. 8 Green blower furnishes blast for the large furnace, and a No. 7 blower of the same type for the small furnace. Both blowers are directly connected to horizontal engines on the same bed-plate. The blowers run from 130 to 150 rev. per min., furnishing blast at a pressure of from 14 to 18 oz. per square inch. The blast main from the large blower is 30 in. in diameter, and that from the small one 24 inches.

The coal is of a very poor grade, being slack from Cambria, Wyo., which costs \$2.75 per ton, delivered at the plant. The ashes are sluiced from the boiler-plant through launders to the slag-dump. The water-supply of the plant is obtained by pumping from Rapid Creek, a few hundred feet below the plant.

SLAGS—Table I, gives the analyses of typical slags made at the plant.

TABLE I—*Analyses of Slags.*

Kind.	Silica.	Ferrous Oxide.	Lime.	Alumina	Zinc Oxide.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Blowing in slag.....	42.55	16.67	30.7	6.85	.....
Typical slag.....	47.5	18.7	28.25	3.5	.....
Typical slag.....	50.2	16.35	28.30	4.2	.....
High alumina and zinc.....	42.86	17.24	26.61	9.39	2.28

The precious metal-content of the slags given in Table I are usually, gold 0.01 oz., and silver 0.20 oz. per ton, a trace of copper also being present.

The limestone used as a flux is very pure, as shown by the analyses given in Table II, and contains only a trace of magnesia. Some magnesia, up to 8 or 10 per cent replacing lime, would be desirable, owing to its greater silica-saturating power, and the lesser specific gravity of the resultant slag. The Golden Reward plant at Deadwood uses a magnesian limestone successfully. At the present time no limestone containing magnesia is available in the vicinity of Rapid City.

The slags are fluid and flow readily from the furnace with a slight arch. They chill quickly, which indicates a rather high temperature of formation. Water-cooled slag-spouts have been tried on the furnaces, but had to be discarded owing to their marked chilling-effect on the slag. The greater part of the slag is granulated by waste water from the furnace-jackets and discharged to flat-cars of the railway which utilizes it as road-

Heated blast is used in smelting. The blast heating apparatus is a U-pipe stove, containing 12 U-pipes each 16 in. in diameter and 10 ft. high. This type of stove is not as efficient as it might be owing to the difficulty in preventing leakage. The stove is placed in the dust-chamber directly beneath the down-take, it being intended to heat the blast only by the waste heat from the furnaces. Under ordinary conditions the temperature of the blast, taken at the tuyeres, is 131° Fahr., with the outside air at 65° Fahr. With the cupelling-furnaces running on some experimental work, the temperature of the blast at the tuyeres was as high as 320° Fahr., with the outside air at 77° Fahr.

[illegible][illegible][illegible]

(ii) Ferric oxide.

The Penobscot ore contains from 0.88 to 0.96 oz. gold and from 1 to 2 oz. silver per ton. The Ben Hur ore contains from 0.73 to 0.85 oz. gold and 1.5 oz. silver per ton. It is generally aimed to keep the ore-value not less than \$20 per ton.

MATTE—The first matte produced is low in copper, containing from 10 to 14 per cent copper and from 4 to 5 oz. gold and from 6 to 7 oz. of silver per ton. The matte-fall figured on the total furnace-charge is from 4 to 5 per cent, this fall being amply sufficient to collect the values. We believe a 3 per cent matte-fall would be sufficient. It was found by experience that some copper was absolutely essential in order to have the matte collect all of the values and at the same time to produce sufficiently clean slags. In 1901, shortly after the plant was started, it was endeavored to run without copper-ores, owing to the difficulty of procuring them. Mattes were made with only a trace of copper in them, but the slags invariably contained from \$1.00 to \$2.50 in value per ton in gold. This loss being too great for profit, copper-ores had to be procured. Upon the addition of copper-ores to the furnace, the abnormal loss of value in the slag disappeared, dropping to the normal value of from 20 to 30 cents per ton and often less. It has been demonstrated by Dr. R. Pearce² and E. G. Spillsbury³ that iron sulphide will not collect gold and silver. Metallic iron will collect gold, but practically no silver, as Dr. F. R. Carpenter has pointed out⁴—a fact which is amply proven by the sows, or metallic-iron accretions, formed in the hearth of the furnace as well as in the fore-hearth. The matte formed rarely contains more than 30 per cent sulphur, while the iron monosulphide contains 36.36 per cent, so that the matte is evidently a subsulphide. It also contains metallic iron, which can readily be abstracted by the magnet. We agree with Dr. Carpenter that it is this metallic iron in the matte which collects the gold, but, unfortunately, it is rarely in the matte in sufficient quantity to give clean slags. Paradoxical as it may seem, the quantity of metallic iron formed in the furnace is due to a large extent to the amount of oxidation which takes place in the furnace. This point is referred to later in this paper under the section devoted to sows.

The amount of oxidation being difficult of control, the matte composition and matte-fall vary from time to time. There are occasions when practically no matte is being made, but at the same time the slags do not increase in value, showing that while no matte is made, metallic iron is being produced. This condition of affairs occurs during periods of much oxidation, and is usually remedied by the charging of extra quantities of pyrite,

²*Trans.*, xviii., 451.

³*Trans.*, xv., 157.

⁴*ibid.*

in order to furnish more sulphur, and leave some to remain in the matte.

Accretions on the furnace-walls will decrease the quantity of matte made, by raising the zones of oxidation. Of course, the quantity and pressure of the blast, also, greatly influence the matte production.

DESULPHURIZATION—The matte-fall being generally but 4 or 5 per cent. shows the great desulphurizing action of the furnace, which amounts ordinarily to from 70 to 77 per cent. To take the workings of a typical day, the quantity of sulphur fed into the furnace in the shape of pyrite was 7,350 lb. and the sulphur in the matte was 2,100 lb., showing a loss of sulphur of 5,250 lb., which is equivalent to 71.5 per cent of the total quantity in the materials charged into the furnace.

The desulphurization-figures for December, 1903, were as follows:—The quantity of sulphur fed into the furnace in pyrite, 175 tons; in matte, 37.5 tons; in copper-ore and concentrates, 27 tons, a total of 239.5 tons. The sulphur in the matte produced was 52 tons, showing a loss of sulphur of 187.5 tons, or 78 per cent of the quantity charged into the furnace.

The sulphur in the materials carried over mechanically in the flue-dust may be disregarded on account of its relatively small quantity and the fact that much of it is in an oxidized condition. The total quantity of flue-dust produced in treating 3,952 tons of charge amounted to 10 per cent, or 395.2 tons, having an average sulphur-content of 3 per cent, which is equivalent to 11.8 tons of sulphur, a large portion being in an oxidized form.

The matte produced without copper-ore was made with the furnace running on pyritous material of the following composition. Iron, 24.52; silica, 27; lime, 3.06; lead, 5.82; zinc, 8.55; sulphur, 28.03; arsenic, 3.4 per cent; copper, trace; gold, 0.04 oz., and silver, 2.86 oz. per ton.

TABLE III.—*Composition of Mattes.*

Kind.	Iron.		Copper.		Sulphur.		Zinc.		Gold.		Silver.	
	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Ounces Per Ton	Ounces Per Ton	Ounces Per Ton	Ounces Per Ton
Made without copper-ore	61.	1.5					2.18		7.1		9.7	
Matte made with little copper-ore	68.5	2.5 (a)			27.1				4.2		8.7	
Matte		2.7							17.65		10.25	
Typical Matte		2.6			30.0				17.11		21.4	
Typical Matte		26.6							11.73		19.7	
Typical Matte		26.3							11.62		18.76	

(a) The slag accompanying this matte had an assay value of \$1.40 per ton.

It is worthy of note that while some of the zinc enters the matte, practically no lead does. The analysis of the slag corresponding to this matte is given in the Table I under the name, "High Alumina and zinc." The quantity of copper in this matte, 1.6 per cent, is insufficient to give a clean slag, which in this instance had a value in gold of \$1.20 per ton. When operations were first started at the plant an experiment was made of adding lead-ores in quantities equaling those of copper-ores now added, to ascertain whether lead would enter the matte and reduce the abnormal losses in the slag. However, no lead was found in the matte, for the reason that the conditions under which the furnace was operated precluded its entrance into the matte. There is so much oxidation that most of the lead becomes volatilized to the great detriment of the yield of silver. Lead, even in small quantities, is very undesirable in sulphide smelting.

The first matte produced is generally resmelted twice, the third matte being the shipping-matte. The Table IV shows the concentration:

TABLE IV.—*Concentration of Gold and Silver in Matte.*

Matte.	Copper.	Gold.		Silver.	
	Per Cent.	Oz.	Per Ton.	Oz.	Per Ton.
First.....	18.5	4.04		6.03	
Second.....	21.5	10.05		15.6	
Third.....	22.6	17.11		21.4	

The matte is cast into slabs in cast-iron molds, in order to break it up readily and have it in a convenient form for shipping.

AMOUNT OF COPPER NECESSARY TO MAKE CLEAN SLAGS—At the present time, copper-ore for the matte is brought from Montana at a considerable expense, and is added in just sufficient quantity to produce the desired effect. It is aimed to have at least 10 lb of copper in the charge for every ounce of gold present, and more, if a supply is available.

The silver is much more affected by the lack of a certain proportion of copper than is the gold. The ratio of silver to gold in the ore is from 1.5 to 2, to 1, and, with an equal saving of both metals, this ratio should be preserved in the matte. Mattes containing less than 20 per cent of copper show a distinct loss of silver. In general, we do not think that sulphide-smelting is adapted to a close saving of the silver.

FUEL—Owing to the high melting-point of the siliceous slags, the quantity of carbonaceous fuel is considerable. The

fuel expressed in percentage of total charge seems very high, but is explained by the very poor quality of the Cambria coke used, the ash amounting to about 30 per cent. Generally a mixture of two-thirds of Cambria coke and one-third of Eastern or Colorado coke is used. The quantity of coke used varies from 14 to 18 per cent of the ores and flux charged into the furnace.

TABLE V.—*Composition of the Coke Used at the National Smelter*

Kind of Coke.	Fixed Carbon.	Volatile Carbon	Ash. (a)	Water.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.
West Virginia.....	85.83	10	12.42	0.69
Cambria, Wyo.....	65.22	3.93	29.93	0.92
Colorado.....	86.86	17	10.7	1.6

(a) The analysis of the ash is given in Table II.

The statistics given in Table VI show a capacity of the small furnace of about 105 tons of burden per day. The large furnace has a capacity of about 130 tons of burden per day. Both furnaces operate under the disadvantageous condition of treating a very large quantity of fines, aside from using such very poor and friable coke.

SOWS—In our opinion the production of sows is practically inseparable from sulphide-smelting when high concentration is done. The sows are due to the strong oxidizing effect of the

TABLE VI.—*Capacity of the Furnaces of the National Smelter.*

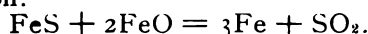
Material.	Smaller Furnace. November, 1903.	Smaller Furnace. December, 1903.
	Tons.	Tons.
Siliceous ore.....	1,100	980
Pyrite.....	512	548
Limestone.....	1,058	1,070
Copper ore etc.....	70	90
Flue-dust (a).....	250	848
Matte.....	136	125
Total burden.....	3,126	3,161
Coke.		
Cambria.....	510	517
Eastern.....	180	162
Fuel percentage.....	18	17

(a) Including accumulated flue-dust from the chlorination works.

furnace, as shown by the following data. A desulphurization of 80 per cent; the production of copper sulphate, found in layers in the accretions of the downtake; no evidence of carbon mon-

oxide in the furnace gases; the volatilization of all the lead fed into the furnace, and the facts that no iron goes into the furnace as oxide, and the slag contains from 18 to 20 per cent of iron oxide in the form of silicate. These data make it difficult to imagine that the reducing conditions in the furnace could exist sufficiently strong to produce metallic iron.

We believe that the sows are produced by oxidation in a similar way that metallic copper is produced during bessemerizing, taking as the first stage, the melting of the pyrite, FeS_2 ; and the loss of the one atom of sulphur forming the monosulphide FeS ; the second stage, the gradual oxidation of the sulphur in the monosulphide, producing a subsulphide; the third stage, the production of some ferrous oxide, part entering the slag, and part reacting with the sulphide present, producing sulphurous acid gas and metallic iron, according to the following chemical equation:



Experience has shown that a larger quantity and higher pressure of blast result in an increased production of metallic iron sow, and, from its analysis, it is seen that it contains practically no carbon, which apparently should be present if the metallic iron was due to the reducing action of the coke.

In the large furnace (38 by 144 in. in cross-section at the tuyeres), a 15-ton sow was produced in a 7-months' run, having an approximate value of \$5,000 in gold. In the smaller furnace in a 3-months' run, under a lower blast-pressure, a 5-ton sow was produced, having an approximate value of \$1,500.

The sow, as a whole, is not homogeneous, and consists mainly of metallic iron containing intermixed slag and a little matte. The metallic iron contains practically no silver, but considerable gold. The iron has a crystalline structure similar to that of pig-iron, possesses a distinct silver color and is practically pure metallic iron. In the large sow some pieces of copper were found. Rarely a small button of lead is found in a sow.

TABLE VII.—*Composition of Sow Produced at the National Smelter.*

Material.	Iron.	Sulphur.	Gold.	Silver.	Copper.
	Per Cent	Per Cent.	Oz. Per Ton.	Oz. Per Ton.	Per Cent.
Average Sow			20.3	2.4	.....
Crystalline iron	99.68	0.2	29.6	4.4	trace
Fore-hearth sow (a)			35.8	nil	14.1
Lead in sow			134.17	273.45	.....
Copper in sow			83.8	nil	.....

(a) A true sow.

Material from the fore-hearth resembling a sow contained, iron, 72.3; sulphur, 19.19; copper, 6.94 per cent; gold, 6.3 oz., and silver, 5.2 oz. per ton. It is usually through the accumulation of this material and that of the true sow that the fore-hearth is lost. The top layer of the sow, as well as that part in contact with the fire brick, is usually of an oxidized appearance.

The treatment of the sows for the recovery of the gold and silver values in them is a difficult problem, especially when no reverberatory furnaces are available. The National Smelter has not this valuable adjunct which is practically necessary for the treatment of the sows and the flue-dust. At the present time the sows are broken up by blasting, a very expensive operation, and re fed into the furnace a little at a time with the pyrite in order to resulphurize the iron.

FLUE-DUST—Owing to the absence of reverberatory furnaces, the flue-dust made amounting in quantity to about 10 per cent. of the charge is resmelted in the blast-furnace, a rather undesirable procedure. Aside from this flue-dust, the plant has treated at times considerable quantities of concentrates from stamp-mills, and accumulated flue-dust from chlorination-plants, so that the quantity of fines was really more than the furnace could profitably handle. In order to put this material through and keep the quantity of flue dust produced within limits, the furnace low in itself, was operated with a low charge, and consequently with a fairly hot top, which accentuated the losses in fume. The flue-dust increases in value as the stack is approached.

TABLE VIII.—*Analysis of Flue-Dust.*

Material.	Fe ₂ O ₃ .	SiO ₂ .	Line.	Sulphur.	Copper.	Gold.	Silver.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Oz. Per Ton.	Oz. Per Ton.
From dust-chamber.....					0.88	1.02	4.1
Beginning of flue (a).....	37.14	3.27	4.12	5.60	0.80	1.17	12.60
▲Average flue-dust (b).....	25.43	.84		4.63(c)	0.80	1.25	13.55

(a) Contains also Al₂O₃ 4.07 per cent.

(b) Contains also 9 per cent carbon

(c) Considerable of which is chlorine water.

TABLE IX.—*Analysis of Accretions in the Dust-Chamber.*

Place.	Carbon	Copper.	Gold.	Silver.
		Per Cent.	Oz. Per Ton.	Oz. Per Ton.
From the bottom of downtake.....	Considerable	14.1	0.70	8.80
On the blast-heating apparatus.....	Considerable.	16.1(a)	0.40	5.1

(a) All soluble in water, for the most part being present in the form of copper sulphate.

The ratio of gold to silver in the ore is usually about 1 to 2, so that the analysis of the accretions shows a heavy loss of silver by volatilization. In fact, the process as a whole is unfavorable to a high recovery of the silver, especially if high concentration is carried on.

LOSSES IN FUME—It has been the experience at the National Smelter that there is a considerable loss of values by smoke and fume, especially in silver, and gold, under certain conditions; as, for instance, when operating with high concentration and lead or zinc in the charge. Lead is not at all desirable in the furnace, most of it being volatilized, carrying values with it.

TABLE X.—*Analysis of Condensed Fume from the National Smelter.*

Place from which Taken.	Gold.	Silver.	Copper.	Remarks
	Oz. Per Ton	Oz. Per Ton	Per Cent.	
Flue near the sack.....	1.50	15.50	Trace	
Middle of flue.....	1.60	11.90		
Near the beginning of the flue.....	1.60	10.40		Contains lead, soluble
Average value of fume from the steel roof of the flue.....	2.00	16.1		suphates, arsenic, some calcium sulphate.

The analyses show the relatively much greater volatilization with the silver suffers, although it is evident that the gold in the ore also suffers loss. As a matter of experience, it might be said that when the furnace is running low with a hot top, and some of the above mentioned undesirable elements present, the monthly account based on the ore-assays, will show a considerable loss in silver, and a very appreciable one in gold, as well as some copper, which are not slag losses. Greater attention paid to the saving of fume in sulphide-smelting plants would lead to economy.

Laboratory Experiments on the Unoxidized Siliceous Ores of the Black Hills.

BY CHARLES H. FULTON.

It is well known that while the "red" or oxidized siliceous, or Potsdam ores of the Black Hills yield readily from 75 to 85 per cent of their gold value to the cyanide process as at present practiced in the Hills, the "blue" or unoxidized ores yield but from 30 to 50 per cent extraction, and are as a general thing the bugbear of the millman. Regarding the occurrence of the "blue ores" in the ore bodies, no distinct line can be drawn separating them from the red ores, the blue ores often being found in bunches and pockets in the red ores, in widely varying quantities. The amount of blue being mined is, however, increasing as the workings penetrate further into the ore bodies. This fact is amply proven by the extraction figures of the various mills which, as a general thing, have dropped from 5 to 10 per cent. within the last two years.

While, as a usual thing, the siliceous ores present the same general characteristics at all of the properties yet ores from the individual mines will vary quite widely as regards amenability to cyanide treatment. The ores can be roughly divided into two general classes, the shale ores and the quartzite ores, of which usually, though not invariably, the quartzite ores are the more refractory, generally on account of their greater compactness and density. There are some blue ores that will not yield more than 20 to 25 per cent of their values to ordinary cyanide treatment, while others will yield 50 to 60 per cent, although the latter percentage of extraction is rare.

The gold and silver values are very evenly distributed throughout the ores as is shown by the assay of different screen sizes*. It is rare that the dust has a higher value than the coarser sizes, and it sometimes has a lesser value. As an example, the dust accumulated on the mill rafters from the dry crushing of ore at the Imperial mill, had a value considerably

*F. C. Smith. The Occurrence and Behavior of Tellurium in Gold Ores, T. A. I. M. E. Vol. 26, p. 491. Similar Experiments made in the laboratory of the School of Mines more recently confirm these results.

less than that of the ore crushed during the time of its accumulation. These facts point to the occurrence of the gold in the ores in a comparatively non-brittle mineral. Just in what form the values do occur has been much speculated on† but it cannot be said that any definite conclusions have been reached. It seems a rather important point to determine, from a metallurgical point of view, as having an influence on the mode of treatment. F. C. Smith states that he has found tellurium in many of the Potsdam ores, and believes that the gold occurs in many instances as sylvanite, although this mineral has never been isolated except in ores from the Ironsides mine, Squaw creek.‡ However, the fact that many analyses made at the School of Mines recently, fail to disclose tellurium or but traces of it, in many ores, lead to believe that tellurium is not of such widespread occurrence in the siliceous ores, as believed, and that the gold bearing mineral is not in most cases a telluride. Experience at Cripple Creek, Colorado, and at Kalgoorlie, Australia, shows that the dust from telluride ores invariably runs higher in value than the original ore. As an example, a Cripple Creek telluride ore shows this result: ‡

Original ore value = 0.82 oz.

Dust, + 200 mesh. value = 1.04 oz.

Dust, - 200 mesh. value = 1.92 oz.

This is due to the extreme sectility of the telluride minerals. As already stated the dust from the Black Hills, siliceous ore rarely has a higher value than the sands.

It has also been found that a cyanide solution plus bromo cyanogen exerts a solvent action on calaverite and possibly similar telluride minerals, as shown by results on a large scale at Kalgoorlie, and by laboratory tests on Cripple Creek telluride ores. For example: A Cripple Creek ore (Vindicator mine) having a value of 1.09 oz. gold, gave 40.4 per cent extraction on raw ore by a 0.4 per cent cyanide solution. A 0.4 per cent cyanide solution plus bromo cyanogen, same time of treatment, gave 91.7 per cent.*

†H. M. Chance, The Discovery of New Gold Fields, T. A. I. M. E. Vol. 29, p. 229, 1033, 1037.

‡F. C. Smith, T. A. I. M. E. Vol. 29, p. 1033.

‡Figures furnished by Mr. John Millikin, Deadwood. The dust mentioned is from the frame work of a Cyanide plant at Florence, Colorado.

*For data concerning Kalgoorlie ores, see "The Diehl Process" by H. Knutzen, T. I. M. & M. June, 1902.

An extended series of experiments with bromo cyanogen (results of which follow) on the "blue" siliceous ores of the Black Hills fail to show such phenomenal results, although an increase of extraction of from 8 to 10 per cent is noticeable.

These facts certainly throw doubt on the supposition that the gold in the siliceous ores is generally in the form of a telluride.

Below are appended a number of analyses of siliceous ores, in which particular attention has been paid to the elementary constituents present in small quantities such as arsenic, antimony, etc.

No. 1 † (blue ore.)	No. 2. † (blue ore.)
Gold.....0.63 oz. per ton.....	0.85 oz per ton
Silver.....2.00 " " "	6.08 " " "
Silica.....65.38 per cent	80.00 per cent
Iron.....13.40 " "	7.50 " "
Sulphur.....11.40 " "	4.40 " "
Arsenic.....0.90.....	2.00 " "
Antimony... trace	0.00
Tellurium...0.003.....	trace
Zinc.....0.00.....	0.00
Copper.....0.02.....	0.004
Manganese...trace.....	0.54
Alumina...5.43.....	1.79
Lime.....2.10.....	1.70
Magnesia...0.20.....	not determined
No. 3.† (blue ore.)	No. 4.† (partially oxidized) ‡
Gold.....3.35.....	2.00
Silver.....1.75.....	0.62
Silica.....80.90.....	84.80
Iron.....9.94.....	7.50
Sulphur.....4.53.....	0.75
Arsenic.....0.29.....	0.00
Antimony...trace.....	0.00
Tellurium...0.007.....	trace
Copper.....0.013.....	0.008
Zinc.....trace.....	0.00
Manganese...trace.....	0.96
Alumina.....1.70.....	1.02
Lime.....0.50 per cent	0.90 per cent
Magnesia...trace.....	not determined
Ore "A"	Ore "B"
No. 5. (blue ore.)	No. 6. (blue ore.)
Gold.....0.78 oz. per ton.....	0.90 oz. per ton

†Kindly furnished by Mr. John Gross, Maitland, S. Dak.

Silver.....	—	—
Silica.....	77.38	93.72 per cent
Iron.....	3.54	2.67 " "
Sulphur.....	4.42	0.69 " "
Arsenic.....	0.55	0.002
Antimony....	trace	0.0893
Tellurium....	none	none
Copper.....	trace	none
Manganese....	none	0.082
Alumina.....	2.80	3.53 per cent
Lime.....	0.56	—
Magnesia....	trace	—
Phos. acid....	0.32	0.0059
Soda.....	1.32	—
Lead.....	—	trace
Thallium.....	?	?
Tungsten....	—	none

In the analyses, copper, antimony, arsenic, tellurium, will be noticed in small quantities in most of the ores. In the Maitland ores bismuth also exists in appreciable quantities for at the Penobscot mill it is found in considerable amounts in the zinc precipitates. Certain peculiar facts are noticed in roasting various blue ores, as a general thing a fair extraction may be obtained on *most* of the blue ores if they be finely crushed and roasted at a low heat for a considerable time. If the heat be raised to a high temperature at once, with some ores but little better extraction can be obtained than from the raw ore. Other blue ores again do not behave in this way. It seems possible that the gold and silver are held in some complex mineral combination into which arsenic and antimony enter, so that a high temperature and oxidizing conditions transform this compound into stable compounds, failing to liberate the gold and silver. The gold and silver bearing mineral is also very uniformly distributed throughout the rather dense ores, so that in most instances a comparatively fine crushing* is required to liberate the values from the rock mass. Roasting of the ores causes practically no loss of values.

The fact that the siliceous ores of the Black Hills were possible telluride ores led to the rather extended series of experiments with bromo cyanogen, which while not giving the results hoped for, aid the extraction of the values somewhat, so that the publishing of the results seems justified. All the tests made were agitation bottle tests, which, is the usual starting point in

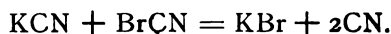
*There are exceptions to this rule, as for instance, certain ores of the Wasp No. 2 mine, and the Ragged Top ores.

experiments of this kind. The results obtained by these were to be confirmed by tests on a larger scale, but unfortunately the time, means and apparatus for this work was not available. The tests were made practically all on the "blue ores" with the idea that the more oxidized ores would be tested later. The effect of bromo cyanogen on the extraction is soon to be tried on a large scale by one or two of the mills of the district, and the results will be watched with great interest.

BROMO CYANOGEN—Bromo cyanogen and chloro-cyanogen were first used unsuccessfully in the Cyanide process by Dr. William H. Gaze, in Australia in 1892. Later in 1894 the use of bromo cyanogen was patented by Messrs. Sulman and Teed in connection with zinc dust precipitation in England. It is at present used in Kalgoorlie, West Australia, in the Diehl process with success, on sulpho telluride ores.†

Bromo Cyanogen above a certain temperature is a pungent irritating colorless vapor, extremely poisonous which affects the eyes and lungs in a very irritating manner. At 60 °C it sublimes into colorless needles, which afterwards change to cubes. The vapor and sublimate is soluble in water and methyl alcohol, more so in alcohol than in water.

When heated in a closed tube to 140 °C it is converted into CN_2 Brs. It is decomposed by potassium cyanide with the following reaction.



With alkalis such as potassium hydrate, the following reaction probably takes place in dilute solution.



PREPARATION OF BROMO CYANOGEN—There are three methods of preparing bromo cyanogen.

1. *By the Addition of Dilute Bromine Water to a Dilute Solution of Potassium Cyanide, the Last Being in Excess*—The amounts of bromine and cyanide are best present in the theoretical quantities expressed by the reaction.

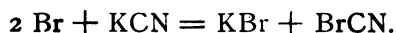
†The Diehl Process, H. Knutzen, T. I. M. & M. June 1902.

Metallurgical Progress in W. Australia, E. & M. Jour. Vol. 75, p. 18,251, also Vol. 77, p. 31.

The Treatment of Sulpho-telluride ores at Kalgoorlie, E. & M. Jour. Vol. 76, p. 156.

The Treatment of Telluride ores by Dry Crushing and Roasting at Kalgoorlie, T. I. M. & M. Oct. 15, 1903.

Cyanide Practice, by Alfred James, 1903.



The bromine water may be added until a faint permanent yellow color appears. The cyanide solution during the addition of bromine water should be kept cold by ice water, as the heat developed by the reaction is sufficient to drive off the bromo cyanogen as a vapor from the solution.

2. *Preparation by Means of Bromine and Mercuric Cyanide.*—When one part of liquid bromine is allowed to flow gradually on 2 parts of mercuric cyanide (dry salt) in a retort* surrounded by ice, bromo cyanogen and mercuric bromide are formed with a great evolution of heat. Bromo cyanogen sublimes in needles contaminated with free bromine, which, however, flows back into the retort and enters into complete combination. Gentle heat, by means of an alcohol lamp, is then applied and the BrCN sublimed into a receiver surrounded by ice water.

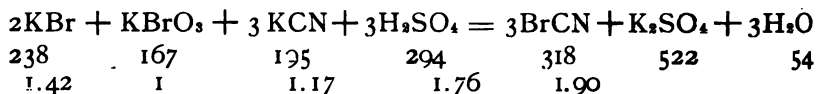
Mercuric cyanide, if not available, can be made by dissolving mercuric oxide, (which can be made from mercury or mercuric nitrate) in a solution of hydrocyanic acid. The hydrocyanic acid can be made with potassium Ferro cyanide or potassium cyanide and dilute sulphuric acid, by heating in a distilling bottle and collecting the vapor in ice water, or water cooled by ice. When the mercuric oxide is all dissolved in the hydrocyanic acid solution in the cold it is gently evaporated to crystals on a water bath, care being taken not to remove the very last of the solution on the bath, but to let it evaporate in the air, or in an air bath at a temperature not exceeding 120° Fahr., otherwise there is danger of reducing the mercuric cyanide.

Bromo cyanogen crystals obtained in this way can be kept in a tightly corked bottle in a cold place for use indefinitely. This method is the most difficult and expensive method of preparation, but yields the pure crystals of bromo cyanogen unadulterated by any other salt. This may sometimes be desirable for certain tests, but for general experimental purposes bromo cyanogen made by the first method, or still better by the third method, to be described, which is the commercial method of its production in Western Australia, is just as desirable.

3. *Preparation by Means of Bromine Salts, Potassium Cyanide and Sulphuric Acid.*—When solutions of potassium

*The apparatus for this work is best a small retort and receiver, the retort having an opening for a small thistle tube with stop cork for the introduction of brome. See Denver Fire Clay catalogue, p. 173, No. 1313.

bromide, potassium bromate, potassium cyanide and sulphuric acid are mixed in the proper proportions, bromo cyanogen in solution is produced according to the following equation:



It is essential for success that the proportions of the theoretical equation be followed closely and that the solution be not too concentrated.

TO TAKE A DEFINITE EXAMPLE:

Taking as the starting point 25 grms. of potassium bromate it will require

1.42 x 25 = 35.5 grms. of potassium bromide
1.17 x 25 = 29.25 " " " cyanide
1.76 x 25 = 44.0 " " sulphuric acid.

This should produce 47.5 grms. of bromo cyanogen. The Potassium bromide and bromate may be dissolved in about 400 c. c. of cold water. It will take some time to dissolve the bromate, as it is rather difficultly soluble in water. The potassium cyanide can be dissolved in 200 c. c. of water, and the required amount of sulphuric acid diluted to 400 c. c.

The strength of the sulphuric acid should be estimated before dilution with an N-10 solution of sodium hydrate, 4 grams to the litre, one c. c. of which is equivalent to .0049 grams of sulphuric acid. The proper amount of sulphuric acid being taken, containing 44 grms., this is diluted to 400 c. c. and allowed to cool thoroughly. In taking the amount of cyanide, care must be taken to allow for the amount of impurity in the salt.

The solutions of potassium bromide, bromate, cyanide and of sulphuric acid are now mixed best by pouring the bromine salts and cyanide solutions simultaneously in a thin stream into a large funnel discharging into a bottle containing the sulphuric acid. It is essential to mix in this way otherwise reactions occur which occasion loss. The best way is to have the two solutions discharging simultaneously in a thin stream from large stop cock funnels.

After the mixing of the solutions the resultant solution should be agitated for about six hours to complete the reactions. The solution is then ready for use, and will contain about 4½ per cent of bromo cyanogen (theoretically in this example 4.75 per cent.)

Pure potassium bromate is a rather expensive salt, \$2.00 per pound if bought in small quantities (although in large quantities it can be had at about 50c per lb.), and in practice as mentioned further on commercial mixed bromine salts are used. For experimental purposes the mixed bromide and bromate salts can readily be made in the laboratory by the addition of liquid bromine to a saturated solution of potassium hydrate. This solution after the addition of bromine is heated until the bromine disappears, when more bromine is added, this being repeated until the red color stays permanently. The solution now contains a mixture of potassium bromide and bromate from which the bromate containing some bromide will separate out first when the solution cools, owing to its inferior solubility. This can readily be removed by filtration and the solution evaporated to the dry salts.

The reaction for the preparation of bromo cyanogen calls for a mixture of bromide and bromate, of which 41.2 per cent should be potassium bromate. If the solution containing the mixed salts made in the way described be evaporated down to dry salt, the mixture will contain considerably less than 4.12 per cent of bromate. For this reason it is desirable to remove successively the salt which settles out from the solution on evaporation and which is at first practically all bromate but gradually decreases in this salt until what precipitates finally is practically only bromide. In this way by having lots of salts, some high in bromate and others in bromide, the proper mixture of the two salts can readily be made especially if some extra potassium bromide, a common salt in the laboratory, be at hand.

The resultant solution should be neutral, as bromo cyanogen shows neutral to methyl orange and phenolphthalein, but may be slightly acid owing to the reactions being incomplete. If it should be acid, this acidity must be carefully neutralized by an N-10 potassium or sodium hydrate solution, care being taken not to add any excess, as this alkali decomposes bromo cyanogen, as already mentioned.

The bromo cyanogen solution prepared in this way is quite stable and keeps a considerable length of time, several months, if kept in a tightly stoppered bottle. It may turn a brown color upon standing, which color is *not* due to free bromine. This color does not interfere with the reactions.

Bromo cyanogen is made on a commercial scale, in Western Australia at Kalgoorlie as follows:*

*A. James, E. & M. Jour. Vol. 77. p. 31.

It is made from imported salts (Germany) which contain approximately 40 per cent of potassium bromate and the balance bromide. At Kalgoorlie to generate 100 lbs. of bromo cyanogen the following charge is used:

Mixed bromo salts,	125 lbs.
Cyanide, 100 per cent	65 "
Sulphuric acid, 70 per cent	147 "

The bromo cyanogen is made in a wooden, plain or lead lined vat of about 200 gals. capacity, securely covered with a lid through which a revolving paddle or stirrer works. Above this vat is a smaller vat in which is stored the necessary charge of potassium cyanide dissolved in 40 gals. of water. The mixing vat is first three-quarters filled with water, the agitator is started and the sulphuric acid added slowly and carefully. The whole is now left to stand and cool for one or two hours, as the heat generated by the addition of sulphuric acid would vaporize the bromo cyanogen were the rest of the ingredients added at once. When the contents of the vat are cool the mixed bromo salts are added gradually and, simultaneously the solution of cyanide is run in with constant stirring. The reaction commences immediately, but is not thoroughly completed until six hours of continuous agitation.

The resultant bromo cyanide solution is then added in the quantities desired to the agitation vats.

METHODS OF ESTIMATING THE AMOUNT OF BROMO CYANOGEN AND POTASSIUM BROMATE.

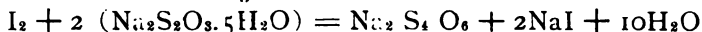
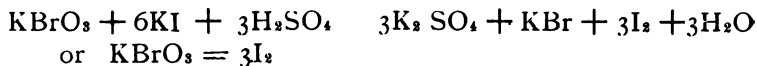
For the quantitative estimation of both potassium bromate and of bromo cyanogen an N-10 solution of sodium-thio-sulphate will answer. This solution will contain 12.4 grams of the salt. ($\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$) and 1 c. c. will be equivalent to

0.00265 grms. of bromo cyanogen,
0.00142 " " potassium bromate.

For the Estimation of Potassium Bromate in the mixed salts of bromide and bromate proceed as follows:

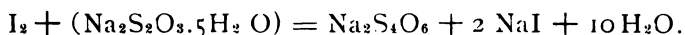
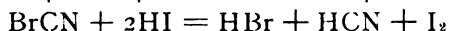
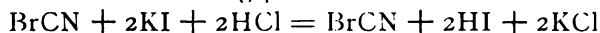
Weigh out 200 milligrams of the dry salt, dissolve in 100 c.c. of distilled water, then add about 15 to 20 c. c. of dilute hydrochloric acid, and 3 to 5 grms. of potassium iodide. Iodine will be liberated and the solution is then titrated to colorlessness by N-10 sodium-thio-sulphate solution. If greater accuracy is required starch solution can be used as an indicator.

The reaction taking place is as follows:



For the Estimation of Bromo Cyanogen take 5 to 10 c. c. of the solution to be titrated, dilute with 25 to 50 c. c. of water, add 5 c. c. of dilute hydrochloric acid and 4 to 5 grams, of potassium iodide. This liberates iodine and the solution is titrated to colorlessness by N-10 sodium-thio-sulphate solution. Or as above, starch solution can be used as an indicator.

The reaction taking place is as follows:



In estimating mill solutions, or solutions that have been used on ores experimentally, and which contain potassium cyanide, the presence of this salt does not interfere with the titration for bromo cyanogen and in the estimation of potassium cyanide in these same solutions with silver nitrate in the usual way, bromo cyanogen does not interfere with the test except in so far as cyanogen, which may be present, due to the reactions between bromo cyanogen and potassium cyanide, interferes.

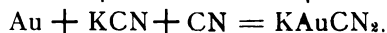
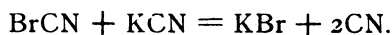
Usually the presence of cyanogen gives somewhat low results.[†]

* *METHOD OF MAKING BROMO CYANOGEN TESTS ON ORES.*—In experimental work the general practice is to add bromo cyanogen in solution to the test at intervals of 2 to 4 hours, the total amount of bromo cyanogen not to exceed one-fourth the amount of the potassium cyanide present in the experiment. As an example, suppose 16 assay tons of ore are treated with 700 c. c. of a 0.25 per cent, or 5 pounds per ton potassium cyanide solution, containing, therefore, 1.75 grams of cyanide. The total amount of bromo cyanogen to be added to this test is therefore 0.44 grams, and having a 3 per cent bromo cyanogen, solution each cc. containing .03 grms. the total number of c.c. to be added of this solution will be 15. If we make three additions at intervals of 4 hours, each we will add 5 c. c. each time.

The theory of the reactions with bromo cyanogen is as follows:

[†] James, Cyanide Practice, 1902, p. 140.

* James, " " 1902, chapter on Bromo Cyanogen



The bromo cyanogen acts as a liberator of cynogen thus practically taking the place of oxygen in the ordinary process. The nascent cyanogen acts as a hastener of the reaction and it is also probable that bromo cyanogen plus potassium cyanide may have a more powerful solvent action on certain gold minerals, such as calaverite, than the simple cyanide solution.

The idea of adding bromo cyanogen in small amounts from time to time is to have the liberation of cyanogen going on during the entire treatment. The greater the amount of potassium cyanide present in proportion to the bromo cyanogen the more rapid is the decomposition of the latter. With additions of bromo cyanogen as described in the test above, there will probably be no bromo cyanogen left in the solution after the expiration of 3 or 4 hours. Any bromo cyanogen left in solution after the expiration of the time of agitation is of course a waste and in tests following the amount may be cut down somewhat if this should be the case.

The consumption of potassium cyanide is greater with bromo cyanogen than without, and this must be taken into account in experimenting, not using too dilute solutions, especially in agitation tests in which consumption is abnormally high.

The solutions from the tests are very often a light brown or golden color, due probably to iron bromide, for more iron salts go into solution with bromo cyanogen than with plain cyanide. The earlier writers[†] dwelt at length on difficulties of precipitating the gold from the solutions when bromo cyanogen is employed, stating that bromo cyanogen has a decided action on zinc forming insoluble zinc bromo and zinc cyanide, which interferes with the precipitation. In the present state of the process there should be no bromide cyanide in the solution when it goes through the zinc, as it should be all decomposed. This difficulty in precipitation seems not to be encountered in West Australia, where bromo cyanogen is used extensively.[‡]

COST OF BROMO CYANOGEN.—The mixed salts of potassium bromide and bromate, containing approximately 40

[†]Gaze—*Practical Cyanide Operations*, 1898, p. 95.

[‡]For certain minor troubles of precipitation, see "Treatment of Telluride ores by Dry Crushing and Roasting at Kalgoorlie, W. A., W. E. Sampson., T. I. M. & M. Oct. 1903.

per cent of the latter salt can be readily obtained in this country* and can be delivered in 500 pound lots packed in barrels f.o.b. Deadwood at 25c per pound. Sulphuric acid costs at Deadwood from 2.6c to 3c per pound and potassium cyanide 23c per pound.

The cost per pound for chemicals, in making bromo cyanogen will therefore be, taking the Western Australia charge as a basis:

125 pounds mixed bromo salts at 24c per lb. =	\$30.00
65 pounds of potassium cyanide at 23c per lb. =	14 .95
147 pounds of 70 per cent sulphuric acid at 3c =	4.41
Total cost 100 lbs. cyanogen	49.36
Cost per pound =	.50

The cost of labor, power, etc., of making may be estimated at 5c more, making a total cost of 55c per pound.

The following tables show concisely the results obtained and the details of the experiments on the blue siliceous ores of the Black Hills. The ores are taken from the various districts, Bald Mountain, Ruby Basin, Maitland and Yellow Creek, so as to give a representation of most of the blue ores.

*Can be bought from the Dow Chemical Company, at Midland, Michigan.

For analysis see previous pages.

ORE "B." A dense blue ore, containing 0.90 oz. gold per ton. Tests made on 2 to 5 oz. lots, amount of solution 200 to 400 cc.

[illegible]

	Temperature.	Time.	Yield.	Per cent. oil.	Centrifuges.	Same.
10	150 mesh	8.9	Low heat, same.	16 lbs. of 4 cc each of a 3% per cent. sol.	48 hours agitation.	8.3
11	150 mesh	8.9	Roasting at low heat plus plain "a" and "b"		48 hours agitation.	1.8
						0.24
						63.5

TABLE III.

ORE "C." A dense blue ore, containing more sulphur than A. or B., containing 0.66 oz. of gold per ton. Tests made on 3 to 5 oz. lots, amount of solution 300 to 500 cc.

Number	Ore passed a following mesh:	Strength of Cy- anide Solution, Pounds per ton.	Method of Treatment	Amount of Br. N. Added.	Time of Treatment	Cyanide Con- sumption, lbs. per ton.	Assay of Tailings oz. per ton.	Per Cent of Extraction.
1	150 mesh	10.6	Plain cyanide, no alkali added.		40 hrs. agitation	8.4	0.32	51.5
2	150 mesh	10	Plain cyanide, treated with KOH. solution for 12 hrs. before cyaniding.		60 hrs. agitation.	2.9	0.33	50.0
3	150 mesh	10	Cyanide and bromo cyanogen, treated with KOH. solution for 12 hours before cyaniding.	6 add. of 4 cc. ea. of a 3.8 per ct. sol.	60 hrs. agitation.	3.7	0.28	57.5
4	150 mesh	15	Roasting plus plain cyanide, low heat for 4 hrs.		24 hours agitation.	2.0	0.24	63.5
5	150 mesh	10	Roasting high heat plus plain cyanide, treated for 12 hrs. before cyaniding with KOH.		44 hours agitation and 48 hours standing.		0.33	50.0
6	150 mesh	10	Roasting high heat plus plain cyanide.		Same		0.35	47.0
7	150 mesh	10	Roasting high heat, cyanide and bromo cyanogen treated for 12 hrs. before cyaniding with KOH.	6 add. of 4 cc. each of a 5 per cent sol.	Same		0.27	59.0
8	150 mesh	10	Roasting high heat plus cyanide and bromo cy- anogen.	Same.	Same		0.29	56.0
9	150 mesh	15	Low heat, same.	4 add. of 2 cc. each of a 3.8 per cent sol.	24 hours agitation.	7.0	0.20	69.5

TABLE V.

Miscellaneous tests. In the main to show efficiency of bromo- cyanogen on certain ores. Tests made on 5 to 8 oz. lots, amount of solution 300 to 500 cc.

NUMBER.	Description of Ore.	Passed through a screen of Mesh.	Method of Treatment.	Strength of Cyanide Solution pounds per ton.	Amount of BrCN Added.	Time of Treatment.	Cyanide Consumption, lbs. per ton.	Assay of Heads oz. per ton.	Percentage of Extraction.
1	Telluride ore, Victor mine, Victor, Colo.	150	Plain cyanide.	8.9		48 hrs agitation.	1.2	1.00	41.2
2	Same.	150	Cyanide plus bromo-cyanogen.	8.9	6 adds. of 4 cc. each of a 3.8 per cent sol.	Same.	4.7	1.00	91.7
3	Keystone concentrates pyrite, containing some arsenic.	table concentrates.	Plain cyanide treated with KOH. before cyaniding.	8.9		Same.	3.6	0.54	88.3
4	Same.	150	Same.	8.9		Same.	3.1	0.54	90.7
5	Same.	150	Cyanide and bromo-cyanogen, treated with KOH. before cyaniding.	10.6	4 adds. of 5 cc. each of a 3.8 per cent sol.	40 hrs. agitation.	6.4	0.40	100
6	Same.	150	Same.	10.6	Same.	40 hrs. agitation.	4.8	0.40	100
	Same.	150	Same.	8.9	6 adds. of 4 cc. each of a 3.8 per cent sol.	48 hrs agitation.	5	0.54	100
	Same.	table concentrates.	Same.	8.9	Same.	48 hrs. agitation.	5.5	0.54	100

SUMMARY OF EXPERIMENTS.—Influence of the fineness of crushing. The size of the ore is stated by "mesh" in the tables which means that the ore passed an ordinary assayer's screen of the mesh stated. For further information the actual size of openings or space and size of wire of these screens is given.

Screen.	Number of Meshes per inch.	Decimal size of wire in inches.	Actual Opening between wires or space in inches.
	20	0.0165	0.0335
	30	0.01375	0.0195
	40	0.01025	0.01475
	80	0.00575	0.00675
	150	0.003	0.0033
	200	0.002	0.003

Material called 30 mesh was sized and gave the following results:

Per cent left on a 40 mesh screen	=	10.4	
" " " " 60 " "	=	29.8	coarser than 100 mesh 66.1 per cent.
" " " " 80 " "	=	16.7	
" " " " 100 " "	=	9.2	
" " " " 150 " "	=	11.7	finer than 100 mesh 33.8 per cent.
" " " passed through a 150 " "	=	22.1	
Total		100.0	

In order to show how this product compares to actual mill products made in the Black Hills the following figures are appended:

PRODUCT OF A SIX FOOT MONADNOCK ROLLER MILL.—Screen, wire cloth with space of 0.046 inches, equivalent to 18 mesh.

Per cent left on a 10 mesh screen	=	1 per cent	
" " " " 40 " "	=	10 " "	coarser than 100 mesh 31 per cent.
" " " " 60 " "	=	10 " "	
" " " " 100 " "	=	10 " "	
" " " " 200 " "	=	19 " "	finer than 100 mesh 69 per cent
" " " passed a 200 " "	=	50 " "	
Total		100. per cent.	

PRODUCT OF STAMPS.—Weight, 950 lbs. Screen 10 by 4 mesh No. 18 wire, space 0.053 inches. Dakota mill, Deadwood.

Per cent left on a 20 mesh screen	= 12.7	} coarser than 100 mesh 55.5 per cent.
" " " " 40 " "	= 22.0	
" " " " 80 " "	= 14.9	
" " " " 100 " "	= 6.0	
" " " " 150 " "	= 14.8	} finer than 100 44.6 per cent.
" " passed thro' 150 " "	= 29.8	
Total	100.0	

PRODUCT OF DRY CRUSHING ROLLS.—Imperial mill, passed through a 16 mesh wire screen, 21 wire space .0305 inches.

Per cent left on a 20 mesh screen	= 3	} coarser than 100 mesh 64 per cent.
" " " " 30 " "	= 18	
" " " " 40 " "	= 17	
" " " " 60 " "	= 16	
" " " " 80 " "	= 5	
" " " " 100 " "	= 5	} finer than 100 mesh 36 per cent.
" passed a 100 " "	= 36	
Total	100	

The effect of the size of ore on the extraction is shown as follows, the results being averages of tests made under same conditions:

Mesh. Laboratory Screen.	Ore A.	Ore B.
40	46.9 per cent.	62.2 per cent.
80	46.9 " "	64.4 " "
150	47.8 " "	64.4 " "

In order to test the effect of still finer crushing Ore A was passed through a 200 mesh screen, but the results were practically the same as with 150 mesh, a trifle lower even.

If, however, the ore is crushed so as to pass but a 20 mesh screen the extraction on all of the ores tested immediately fell off in such a manner that no further tests were made on such coarser sizes. The results of these tests are in accordance with the practice of the plants of the Black Hills, as will be seen by referring to the analyses of the mill products of several plants on the preceding pages. The product of rolls and screens at the Imperial mill is very close to that of a 30 mesh laboratory screen except that it contains a small percentage of somewhat coarser sands. The product of stamps at the Dakota mill, Deadwood,

contains a somewhat greater percentage of fines, (above 100 mesh) and less sands, but a considerable percentage of the sands is coarser than 40 mesh.

In the product from the Monadnock Roller mill the sands are considerable less in amount than in the product of the 30 mesh laboratory screen and the fines considerably more. This product is probably better suited for extraction than the stamp battery product above mentioned. In general it is true that while individual blue ores will differ somewhat in the fineness of crushing required, material that is coarser than 30 to 40 mesh (0.0195 to .01475 inches) will show an appreciable decrease in extraction. Product finer than 40 mesh (.01475 inches) will in general show but little better extraction, perhaps 2 to 3 per cent, than 40 mesh material. It seems, therefore, that for the greater portion of the denser silicious ores very fine crushing presents no advantage whatever, but that efforts directed toward keeping practically all of the sands finer than 30 mesh and preventing excessive sliming as an unnecessary evil is what is called for.

Tests that have been made on sand tailings at the Dakota mill show practically that all the sizes of sands, except the ones coarser than 30 mesh, have the same value.

THE EFFECT OF BROMO CYANOGEN.—The effect of bromo cyanogen while not what was hoped for is still very marked on all of the blue ores treated raw as the following table will show:

Ore.	Percentage of Extraction. Plain Cyanide.	Percentage of Extraction. Cyanide plus Bromo Cyanogen.	Increase in Extraction.
A	$\left\{ \begin{array}{l} 54 \text{ per cent} \\ 39 \text{ per cent} \end{array} \right.$	$\left\{ \begin{array}{l} 63 \text{ per cent} \\ 46 \frac{1}{2} \text{ per cent} \end{array} \right.$	$\left\{ \begin{array}{l} 7.0 \text{ per ct} \\ 7.1 \text{ per ct.} \end{array} \right.$
B	43 per cent	64 per cent	21.0
C	$\left\{ \begin{array}{l} 51 \text{ per cent} \\ 50 \text{ per cent} \end{array} \right.$	$\left\{ \begin{array}{l} 57.5 \text{ per cent} \\ 57.5 \text{ per cent} \end{array} \right.$	$\left\{ \begin{array}{l} 6.5 \text{ per ct.} \\ 7.0 \text{ per ct.} \end{array} \right.$

The effect of bromo cyanogen on roasted ore is not so marked, but still strong in evidence as the following table will show:

Ore.	Percentage of Extraction by Roasting plus Plain Cyanide.	Percentage of Extraction Cyanide plus Bromo Cyanogen.	Increase in Extraction.
A	{ 75.5 per cent { 80.7 per cent { 78.6 per cent { 82.0 per cent	{ 75.5 per cent { 85.8 per cent { 87.1 per cent { 82.0 per cent	{ no { 5.1 per ct. { 11.5 per ct. { no
B	73.3 per cent	81.0 per cent	8 per cent
C	{ 63.5 per cent { 63.5 per cent { 50.0 per cent	{ 69.5 per cent { 65.0 per cent { 57.0 per cent	{ 6 per ct. { 1.5 per ct. { 7.0 per ct.

The effect of bromo cyanogen on the siliceous ores of the Black Hills is to act merely as an accelerator in the solution of the gold bearing mineral as the following table shows:

Ore	Percentage of Extraction by Plain Cyanide, 3 days contact and 4 hours agitation.	Percentage of Extraction by Cyanide and Bromo Cyanogen, 3 to 4 hours agitation.	Percentage of Extraction by Plain Cyanide, 24 hrs. agt.
A	53 per cent	48.7 per cent	39 per cent
B	71 per cent	61.4 per cent	43 per cent

The effect of treating the raw ores for a considerable period with a dilute caustic alkali solution before cyaniding has a marked effect on the extraction in some cases.

	Extraction by Plain Cyanide Without Alkali Treatment.	Extraction by Plain Cyanide and Alkali Treatment.	Extraction by Cyanide plus bromo cyanide plus alkali treat.
A	39 per cent	54 per cent	64 per cent

THE EFFECT OF ROASTING.—The effect of roasting on the ores is of course pronounced, but in some instances does not accomplish by any means what might be expected of it. Some of the ores in order to get extraction must be roasted with great care as regards temperature. The temperature must be kept low, not above a very dull red heat for 3 to 4 hours, when it may be raised to decompose any sulphates formed. If the temperature be raised to a bright red heat, early in the roasting, *with some ores*, but very little better extraction than on raw ore can be obtained. This is perhaps due to the presence of small amounts of arsenic and antimony that form stable insoluble compounds, locking up the gold and silver val-

ues. The effect of roasting can be seen from the following table:

Ore	Extraction by Plain Cyanide, Raw Ore.	Extraction by Plain Cyanide, roasted Ore.	Increase in Extraction.
A	$\left\{ \begin{array}{l} 39 \text{ per cent} \\ 33 \text{ per cent} \end{array} \right.$	$\left\{ \begin{array}{l} 82 \text{ per cent} \\ 75 \text{ per cent} \end{array} \right.$	$\left\{ \begin{array}{l} 43 \text{ per ct.} \\ 42 \text{ per ct.} \end{array} \right.$
B	$\left\{ \begin{array}{l} 47 \text{ per cent} \\ 40 \text{ per cent} \end{array} \right.$	$\left\{ \begin{array}{l} 76.6 \text{ per cent} \\ 73.3 \text{ per cent} \end{array} \right.$	$\left\{ \begin{array}{l} 29.6 \text{ per ct} \\ 33.3 \text{ per ct} \end{array} \right.$
C	$\left\{ \begin{array}{l} 50 \text{ per cent} \\ 51 \text{ per cent} \end{array} \right.$	$\left\{ \begin{array}{l} 63.5 \text{ per ct.}^* 50 \text{ per ct.}^\dagger \\ 69.5 \text{ per ct.}^* 56 \text{ per ct.}^\dagger \end{array} \right.$	$\left\{ \begin{array}{l} 13.5 \text{ per ct} \\ 18.5 \text{ per ct} \end{array} \right.$

With ore B, roasting at a low heat for several hours, and then mixing with charcoal and reroasting was tried, but with no better effect than before.

TIME REQUIRED FOR THE EXTRACTION OF THE VALUES.—Twenty-four hours continual agitation is about the minimum limit of time in order to get the extraction the ore will yield. Below that extraction will suffer materially. Increased time of agitation 36 to 48 hours, gives a somewhat increased extraction, but after that the increase of time gives but little increase of extraction, although of course a constant increment of increase is noted, * if the formation of soluble sulphides be avoided by the addition of a soluble lead salt or zinc sulphate in small quantities.

GENERAL.—A chlorination test on the ore B after roasting was made and gave an extraction of 75.5 per cent as compared to 81 per cent by roasting, cyanide and bromo cyanogen. Ore B, 150 mesh material, was also treated with a solution of aqua regia with boiling to see the effect and an extraction of 84.4 per cent was made, showing the exceeding refractoriness of a portion of the values in this class of ores.

From the experience gained in the tests made it seems that a portion of the values of the blue ores are practically insoluble in a cyanide solution, and that this insoluble compound is in many instances only partially altered by roasting.

If a portion of the values were locked up in the gangue of the ore so that it could not be extracted for this reason, it would seem

* Roasted at low heat.

† " at once at a high heat.

* See also Bulletin No. 3 South Dakota School of Mines. Cyanide experiments, by G. H. Clevenger and A. Forsyth.

that such fine crushing as 200 mesh would certainly liberate the greater part of it and thus permit a decided increase of extraction. But this is not so as can be plainly seen from the experiments. For these reasons the low extraction in most cases must be ascribed the non-solubility of a compound containing a portion of the values, and any effort toward finer crushing beyond the limits specified above, or a continued contact or leaching for a long time will be without results. However the time of treatment given the ores is a very important matter, as it must be continued long enough to be well above the minimum. There is also some evidence that when the time of treatment is continued for a considerable period of time that soluble sulphides tend to form which may lower the extraction unless some zinc be present in the solution to prevent their presence which, however fortunately, is usually the case in ordinary mill solutions.

METHOD OF APPLYING THE BROMO CYANOGEN TO THE MILL SCHEME OF THE WET CRUSHING PLANTS.—This is largely a matter of experiment, but the first addition might take place just before the solution enters the battery. A 3 to 5 per cent bromo cyanide solution could be introduced by a small pipe into the battery mains and regulated to furnish an amount of bromo cyanide solution so that the battery solution would contain, say, 0.01 per cent to 0.02 per cent of bromo cyanide. If added in this place the agitation given by the stamps could be taken advantage of. There is probably one very serious objection to the addition of bromo cyanide to the mill scheme as at present carried out and that is the alkalinity of solutions due to the lime added. As pointed out, alkalis destroy bromo cyanogen, probably without the formation of cyanogen, and it is very likely that the alkaline earth hydrates will do the same. It may be possible that if the battery solution entering the batteries carries but very little protective alkalinity and the amount of lime added with the ore be cut down as low as possible, something might still be accomplished with the bromo cyanogen.

This is a matter of experiment. In West Australia* at Kalgoorlie, lime is added after the agitation of the pulp with cyanide and bromo cyanogen solution, but as the solutions are re-

* The Diehl process, by H. Knutzen, Trans. Ins. M. and Met. June 19, 1902.

used must contain some lime when used with the bromo cyanogen.

The next place where an addition of bromo cyanide can be made is during the first addition of barren solution to the slimes. It could be added in amount so that the resultant solution in the slimes vat will contain from 0.01 to 0.02 per cent bromo cyanogen. If desirable another addition of bromo cyanogen solution may be made at a subsequent addition of barren solution.

The constant addition of bromo cyanogen to the battery solution would, however, require considerable bromo cyanogen per day and unless a rather marked increase of extraction, due to its addition, could be noticed, would hardly be profitable.

For example, in a plant crushing 125 tons of ore per day using 4 tons of a 2 pound battery solution, per ton of ore, the amount of bromo cyanogen required would be 120 pounds, in order to get 0.01 per cent of bromo cyanogen in the battery. This would cost \$66 exclusive of an increased consumption of potassium cyanide due to the addition of bromo cyanogen.

On \$8 ore, therefore, in order to make the addition of bromo cyanogen profitable, an increase of at least 7 per cent must be shown in the extraction, due to the addition of the bromo cyanogen to the battery alone. The question would have to be worked out on a working scale in the mills themselves, and the cost of the experiment would not be very great, as experiments go.

The Crushing in Cyanide Solution Process as Carried on in the Black Hills of South Dakota.

BY CHARLES H. FULTON.

INTRODUCTORY.-- The crushing in cyanide solution process was first introduced into the Black Hills at the old Dakota plant at Central City by Mr. John Hinton. The method originated in New Zealand, being first used by F. R. W. Daw in 1897, at the Crowns mine. In the Black Hills it has become practically the established method for the denser siliceous ores, there being at present five plants in operation using this method, with several more of the same kind projected. The dry crushing process still holds its own on the more porous and open siliceous ores and there are also plants in operation which do fine dry crushing, on dense siliceous ores. The mills employing the crushing in cyanide solution process are the Horse-shoe mill, 120 stamps, 60 in operation; the Dakota mill, 30 stamps; the Maitland mill, 40 stamps; the Hidden Fortune mill, 60 stamps, and the Lundborg, Dorr & Wilson mill, a six foot Monadnock Roller mill.

THE NATURE OF THE ORES TREATED.--For information on this subject reference is made to the foregoing paper.

GENERAL FEATURES OF THE PROCESS.

The process comprises the following operations:

1. The crushing of the ores, generally by stamps, in a cyanide solution ranging from 1.3 to 2.2 pounds of cyanide per ton, and carrying a protective alkalinity, equivalent to 1 to 1.5 pounds of sodium hydrate per ton.
2. The separation of the sands from the slimes by means of cone classifiers.
3. The treatment of the sands by percolation.
4. The treatment of the slimes by agitation and decantation.
5. The precipitation of the values by means of zinc thread.

The process is applicable to the dense siliceous ores that require a comparatively fine crushing and which contain but a small quantity of cyanide consuming compounds. For ores that

without previous alkaline treatment destroy much cyanide the process is not applicable. As a matter of fact it may be stated that the cyanide consumption in this method is higher than in dry crushing. The cyanide consumption in the wet crushing mills of the district varies from 0.75 to 1.50 pounds per ton of ore treated. At a typical dry crushing plant, the Imperial mill at Deadwood, milling the same class of ore, the consumption is 0.4 pound per ton. At the other dry crushing plants of the district it ranges from 0.4 to 0.75 pound per ton. The increased consumption of cyanide is a defect inherent in the process for several reasons. 1. Agitation of the ore with cyanide solution in the battery causes extra consumption. 2. Although the battery cyanide solution carries a protective alkalinity (alkalinity above that due to cyanide and cyanogen compounds) of from 1 to 1.5 pounds per ton, this does not by any means completely protect the cyanide from destruction by cyanicides. The reaction between cyanicides and cyanide and alkaline earth hydrates and caustic alkalis probably takes place in part at least simultaneously. It has been recognized by metallurgists that with many ores it is essential to apply a comparatively highly alkaline solution low in cyanide to the ores before the stronger cyanide solutions are employed, for the alkalinity carried in the strong cyanide solution would be ineffective in preventing a considerable consumption. 3. There is also an increase in the consumption due to the discharge of considerable cyanide in the moisture going out with the slimes tailings. This might be called a mechanical consumption. This consumption alone amounts to from 0.3 to 0.6 pounds per ton of ore treated. The mechanical consumption of dry crushing plants is but an insignificant factor.

At the present time it is difficult to make a comparison as regards the relative merits of the process under discussion and the dry crushing process. There is probably, on the whole, little difference between the two processes as regards cost although the wet crushing mills probably have a slight advantage in this respect, in spite of the slimes treatment and the higher consumption of chemicals. The wet crushing plants, of course, have an advantage in that they do not suffer from the dust nuisance. However, the hope that the wet crushing plants, on account of the great fineness of crushing that could be carried on, would be able to treat the blue ores in the raw state successfully, has not been verified and it is probable that for this class of ores roasting will finally have to be resorted to. In this case, of course,

dry crushing will have all the advantage. Some of the mines of the district furnish but little blue ore, while others have a great deal in their reserves. For the first type the crushing in cyanide solution method is, without doubt, a permanent institution.

THE CRUSHING OF THE ORES.—The ores are rough crushed generally by Gates crushers and in one instance, at the Maitland mill, by a Blake crusher. The crushed ore will pass a 1.5 to 2 inch ring and is fed to the stamps by Challenge feeds. Stamps with one exception are used for the fine crushing of the ore. The Lundberg, Dorr & Wilson mill employs a 6 foot Monadnock roller mill for the fine crushing, a set of rolls being placed between the Gates crusher and the roller mill, in order to get the proper sized feed of ore.

The following table gives the details of the stamps at four of the mills.

Details of the Stamp Mills.

Name of Mill	Weight of Stamp	No. of Drops per Min.	Height of Drop, inches.	Length of Discharge, in.	Width of Mortar Box at Discharge Level.	Screen Used	Amount of Solution per Ton of Ore.	Capacity per Stamp in tons per 24 hrs.	Type of Mortar.
Hidden Fortune*		98	7	8	16	24 mesh wire	5	4	Double issue rear blocked up.
Maitland.....	910	97	7 to 8	6	13	24 by 4 mesh, 20 mesh wire.	4 to 5	3 to 4	Single issue.
Dakota.....	950	88	8	9	15	10 by 4 mesh, 20 mesh wire.	5	4.4	Single issue.
Dakota.....	950	88	8	7	22	Same.	5		Double issue rear blocked up.
Horseshoe.....	1000	90	8	5 to 6	18	14 by 7 mesh, 20 mesh wire	6	4 to 5	Double issue rear blocked up.

*Crushing in very dilute cyanide solution and amalgamating with inside plate and over tables.

Some of the earlier mills installed double issue mortars with the idea of getting an increased stamp duty, but it was soon found that the amount of solution required in crushing was so great that the mills were unable to handle it economically and the rear discharges were closed by wooden frames. It will be seen from the table that the depth of issue and the width of the mortar at the discharge level vary considerably at the different mills. The weight of stamp has not so great a variation.

As the stamps used are for crushing purposes only at all of

the mills with the exception of the Hidden Fortune, it would seem that in general a narrow box, a shallow discharge and a heavy stamp, up to 1100 to 1200 pounds would give the greatest capacity and most economical results. However, the retaining of the ore in the mortar for a certain length of time in order to agitate thoroughly with cyanide solution is desirable. At most of the mills from 50 to 53 per cent of the values of the ore are extracted in the batteries and the classifying cones. Stamps for this type of crushing should attain a capacity of 5 tons and over per stamp, and in the later designs of mills to be built this has been provided for. At some of the mills the ore is very hard which in part accounts for the rather low capacities.

The screens used also vary considerably at the different mills, ranging from 25 mesh, 26 wire, to 10 mesh, 20 wire. This is necessitated by the requirements of the individual ores which, while having the same general characteristics, differ somewhat in the fineness of crushing required.

Recently several of the mills have installed wire cloth screens in which the opening is rectangular, instead of square, the long dimension in these screens being from 2 to 2.5 times that of the short dimension. Screens of this type give somewhat greater capacity and do not choke so readily as screens with a square mesh.

The denser siliceous ores require a comparatively fine crushing, but if the crushing is carried beyond a certain fineness nothing is gained in extraction and trouble is encountered in the production of an excessive amount of slimes which are difficult to handle in the mill. It has been demonstrated that if the ore is crushed so that the great bulk of it is not coarser than 30 mesh (0.0135 inches) and not finer than 60 mesh, (0.0075 inches,) the economic extraction is obtained. Material finer than 60 mesh yields but very little higher extraction than that between 30 and 60 mesh.

The 5 per cent greater extraction obtained in the mills on the slimes, although the recovery is the same as on the sands, is for the greater part due to the agitation obtained in the treatment. If the size of the ore particles however is coarser than 30 mesh the extraction on most of the ores is materially decreased.

The following table shows the nature of the mill product made at some of the mills:

Mechanical Analyses of Mill Products.

Percentage Remaining on Screen.	Mesh of Screen	Name of Mill.		
		Dakota Samps. Screen 10 by 4 mesh 20 wire.	Lundborg, Dorr & Wilson Monadnock Roller Mill, Screen 18 Mesh, 0.046 i space	Imperia', R IIs. Screen 16 mesh, 21 wire.
	plus 20	12.7 per cent.	1.0 per cent.	3.0 per cent.
	plus 30			18.0 per cent.
	plus 40	22.0 per cent.	10.0 per cent.	17.0 per cent.
	plus 60		10.0 per cent.	16.0 per cent.
	plus 80	14.8 per cent.		5.0 per cent.
	plus 100	6.0 per cent.	10.0 per cent.	5.0 per cent.
	minus 100			36.0 per cent.
	plus 150	14.8 per cent.		
	minus 150	29.8 per cent.		
	plus 200		19.0 per cent.	
	minus 200		50.0 per cent.	

The Dakota mill uses the coarsest screens of any of the mills and gets a product about 20 per cent of which is coarser than 30 mesh, a rather high percentage, but in view of the very low tenor of the ores treated, and their shaly nature, this crushing is the most economic that could be practiced. The other mills use finer screens and their mill product approaches closely to that of the Monadnock mill quoted in the above table. One mill, the Hidden Fortune, crushes some cement ore which contains a considerable coarse free gold. This mill has adapted the crushing in cyanide solution process in conjunction with amalgamation inside and outside of the mortar. A very weak cyanide solution, 1.5 pounds per ton, is used with success as a battery solution, no difficulty being experienced to get good amalgamation. The plates need somewhat more frequent dressing owing to the hardening action of the cyanide on the

amalgam.* It is also very probable that the plates will have to be more frequently renewed owing to the solvent action of the cyanide.

WEARING PARTS OF THE STAMP MILLS.—Most of the mills have adopted chrome steel for shoes and in part for dies as giving the most satisfaction and being the most economical. Table III, compares the different materials that have been used.

The Cost of Shoes and Dies of Different Material.

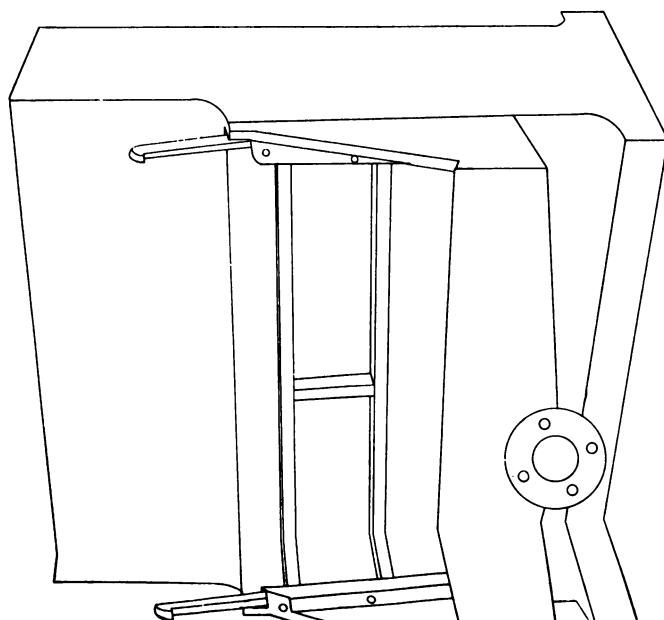
Note. Shoes weigh 180 pounds and dies 120 to 140 pounds. Laid down at Terry, S. D., chrome steel costs 5.83c per pound, Wilson forged steel, 5.72c per pound, and cast iron, 3.5c per pound.

Name of Mill.	Name of Part.	Material	Tons of Ore Crushed.	No. of Days Used.	Cost per Ton of Ore Crushed.
Maitland	Shoe	Chrome steel	250	90-95	4.9c
"	"	Cast iron	105	35-40	4.45c
"	Die	Cast iron	105	40	3.28c
"	"	Wilson forged steel	280	105	3.06c
Horseshoe	Shoe	Chrome Steel	336	84	3.12c
"	"	Cast iron	104	26	6.18c
"	"	Wilson forged steel	280	70	3.67c
"	Die	Chrome Steel	400	100	2.29
"	"	Cast iron	120	80	4.08
"	"	Wilson forged steel	140	85	2.35

The Dakota mill also uses chrome steel shoes and is experimenting with a cast iron die containing 20 per cent of chrome steel scrap, made at a local foundry, which costs 3.5c per pound laid down at the mill. Dies of this kind weigh 120 pounds and lasted 46 days, crushing 175 tons of ore and leave 14 pounds of scrap which is sold at 0.5c per pound.

At the Lundborg, Dorr and Wilson mill at Terry a 6 foot Monadnock roller mill is used to crush in cyanide solution in

* This same method is used, in part at one or two mills employing the Diehl Process at Kalgoorlie, Australia. See the Diehl Process, H. Knutzen, Trans. I. M. and M. June 1902.



Mortar Box for Crushing in Cyanide Solution.

amalgam.* It is also very probable that the plates w
~~be more frequently~~

place of stamps. This mill crushes about 70 to 90 tons of ore per day, from 0.75 inch size through an 18 mesh screen, 0.046 inch space. The mill makes 32 revolutions per minute and has 19.5 square feet of screen area. A peculiar feature in the wear of this mill is that both the die ring and the roller tire cup on wearing, instead of the die cupping and tire crowning. This however does not seem to affect the efficiency of the crushing. The mill is giving satisfaction but no figures are as yet available to afford a comparison between it and the stamps on siliceous ore. It might be stated that the ores crushed at this mill are in part comparatively soft although some hard blue quartzite ores are also being crushed.

The cyanide solution is introduced into the batteries at most of the mills, by two 1.5 inch pipes entering at the front of the battery between the first and second and the third and fourth stamps. Each pipe is controlled by an iron cock.

At two of the mills a special form of mortar is used having a cast iron collecting launder bolted on at the front, and having a central discharge into the main launder collecting the sludge from all the batteries. This mortar is shown in the accompanying plate which also gives the form and dimensions of the mortar used at the Maitland mill. Generally all the screens are overhung with heavy canvas to avoid splash.

THE SEPARATION OF THE SANDS FROM THE SLIMES BY MEANS OF CONE CLASSIFIERS.—

This is now done in the district almost entirely by means of simple sheet iron cones. These cones are the outer cones of ordinary hydraulic classifiers, the inner cones having been removed. It may be stated at the outset that the problem of removing the sands from the slimes when crushing in cyanide solution with considerable lime is a more difficult problem than when crushing in water with practically no lime. The lime causes much trouble, first, by its coagulating effect on the slimes, causing them to settle with the sands and coat sand particles with slimes, and second, by causing the formation of an excessive amount of froth or foam, which is certainly a great nuisance about the mill. The plate accompanying this part of the paper shows the general arrangement of the classifying cones.

The batteries discharge their sludge by launder into a central sump from which it is raised to the cones. The raising

pump at three of the mills is the Frenier Spiral sand pump, and at one of the mills a centrifugal pump. For the raising of the battery sludge consisting of sands and slimes the Frenier pump is preferred to a centrifugal on account of less wear. For the transference of slimes and for their agitation a centrifugal pump is generally used. The usual size of the spiral sand pump employed is the 54 by 10 inches. These pumps are run at 19 to 20 revolutions per minute, raising the pulp 15 to 20 feet. Twenty feet is about the practical maximum lift of these pumps and for greater lifts they are placed in tandem. A pump of the above size will readily handle from 350 to 450 tons of sludge per day.

The discharge of these sand pumps is intermittent so that at all of the mills a distributor box is used to steady the flow and give a uniform feed to the cones. These distributing boxes have different forms at the various mills. At the Horseshoe mill a pyramidal box is used 4 by 4 feet in cross section at the top, the sides sloping at 60 degrees to meet at a point. The inverted pyramid is topped by a box 12 inches high through which the two 4 inch pipes from the sand pumps enter. About 12 inches from the bottom of the pyramid four three inch pipes emerge one at each side, which feed into four 50 inch cones. The distributor is placed centrally over the four cones and as low as possible so that the head under which the discharge takes place will be small. A screen placed in the distributor box serves to keep out foreign matter from the cones. At the Maitland mill a plate steel box 6 by 3 feet in cross section and 3 feet deep is used as a distributor. On one side 21 inches from the top two 5 inch pipes enter from the sand pumps and discharge upon an inclined screen. The two discharge pipes 5 inches in diameter which feed the two 50 inch cones have their centers placed 4 inches above the bottom of the distributor box. As at the Horseshoe mill the distributor is set as closely as possible to the cones. At the Dakota mill a similar box made of wood is used.

The upper cones are simple cones of sheet iron from 40 to 50 inches in diameter having vertical sides at the top 12 inches high. The slope of the cones is 60 degrees ending in a six inch sorting column, which has a two inch discharge controlled by an iron cock. The charging pipe feeds at the center of the cone just below the pulp level. In most of the mills the top cones are covered closely by either a wood or an iron

cover to confine the foam. This has the disadvantage, not very serious, of preventing ready inspection of the cones.

The upper cones are practically simple settling cones. The sludge going to the cones contains from 14 to 19 per cent of solids of which 30 to 50 per cent is slimes and the rest sands. Just what constitutes sands and slimes is somewhat difficult to define.* It is rather generally accepted by the men in charge of the plants, crushing siliceous ores, that material finer than 150 mesh is a slime and coarser than 150 mesh a sand, and classification is made largely on this basis. It has also been defined as that portion of the crushed ore that will make water muddy, sands, no matter how fine, settling practically at once and not remaining suspended.†

The overflow from the upper cones contains practically no sands, even very fine, and goes to the slimes tanks by the overflow launder. The sands discharged at the bottom of the cones contain from 20 to 35 per cent of slimes and are distributed by a short box to the lower cones. These lower cones are of the same construction as the upper ones, but have introduced into the sorting column an upward current of cyanide solution either battery solution or barren solution (solution that has been precipitated), but generally battery solution. This solution is introduced through a 2 inch pipe with a cock to regulate the flow. The amount of solution introduced in this way amounts to from 60 to 80 tons per 24 hours for a 42 to 50 inch cone. These figures vary somewhat, those given representing the limits. The number of lower cones is always one-half that of the upper cones. The solution pipes entering the sorting column of the lower cones do not come directly from the stock tanks, but from a special box provided with an overflow at a definite height, so that the head of the entering solution is always constant.

The final sand discharge containing 25 to 30 per cent solids, and containing from 1 to 5 per cent of slimes, goes to the Butters distributors over the sand vats, battery solution being added in the carrying launder so as to have 5 parts of solution to 1 part of sand. The mills endeavor to make a fairly close separation of sands from slimes in order to get a good leaching rate in the sand tanks, usually from 2.5 to 3.5 inches

*What constitutes a slime? W. J. Sharwood, E. & M. Jour. vol. 76, p. 539, 650.

†Thus defined by Mr. John Gross, in a paper read before the Black Hills Mining Men's Ass. "Cyanide Practice at the Maitland Properties."

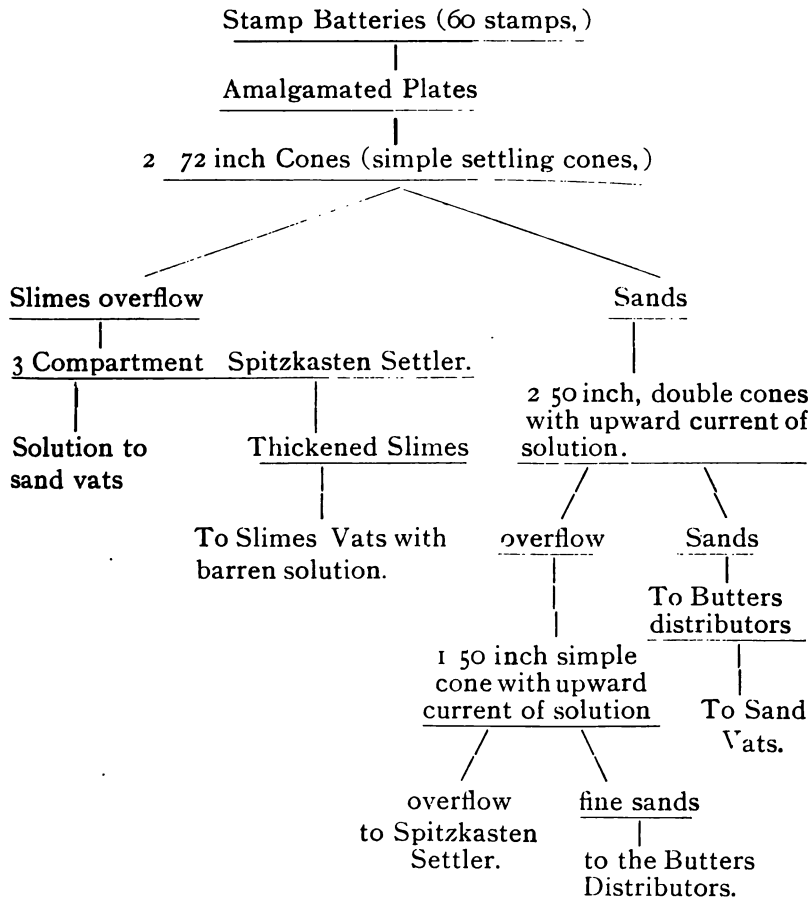
per hour, although at one plant it is but 1.5 to 1.75 inches per hour and also to prevent trouble which the sands give in the slimes tanks, that of settling to the bottom and remaining there during the greater part of the treatment practically unacted upon.

A very close and satisfactory separation however is not possible, first on account of the inherent defects of the cones used as classifiers and second because of the bad effect of the lime in sending slimes with the sands as already mentioned. For these reasons the classification adopted is that of making a clean sand rather than a clean slime, this being the lesser of two evils. For example at the Maitland mill the sands carry only one to two per cent of slimes, five per cent giving an unsatisfactory leaching rate. In making sands of this kind the slimes run from 15 to 20 per cent of fine sands, but a small portion of which remains on a 150 mesh screen. The proportion of the ore crushed treated as sands and slimes varies at the different mills. At the Maitland mill the average figures for 8 months show 48.2 per cent of the ore treated as sands and 51.8 per cent treated as slimes. At the Dakota mill the sands amount to 65 to 70 per cent and the slimes to 30 to 35 per cent. At the Lundborg, Dorr and Wilson mill the sands and slimes amount to approximately 50 per cent in each case. At the Horseshoe mill the slimes amount to 26 to 30 per cent and the sands to 70 to 74 per cent.

A number of different systems of classification by the cones were tried before the system described was adopted. It will be noticed that the system now used reclassifies the sands from the upper cones. Formerly the plan was to reclassify the slimes overflow from the upper cones in the lower cones, but this practice was soon discarded as unsatisfactory, giving in some instances unleachable sands. Double cones were also used, i. e. the regulation cone classifier, but most of the mills now classify with the inner cone removed. The only mill where a double cone with an upward current is used to reclassify the sands is at the Hidden Fortune mill.

Two of the mills, the Lundborg, Dorr & Wilson and the Hidden Fortune, unwater the slimes before they go to the slimes tanks. The first by means of a large sheet iron cone 22 feet in diameter, the top portion sloping 40 degrees and the lower portion near the discharge 60 degrees, and the second by means of a 3 compartment spitzkasten 40 feet long, 6 feet wide and 8 feet deep. The compartments are charged successively and

the thickened slimes drawn off and mixed with solution in the launder that transfers them to the slimes tanks. The object of unwatering the slimes in this way is to give them an additional treatment with barren solution, for when not unwatering the slimes they go to the slimes vat with battery solution and are settled there for the first time, while with the unwatering device the slimes go to the slimes tanks with barren solution having had one dilution by the time they reach the first slimes tank. The scheme of classification at the Hidden Fortune mill is given below as it is somewhat different from that of the other mills:



To show the nature of the classification at some of the mills the following mechanical analyses of sands and slimes is appended:

MECHANICAL ANALYSES OF SANDS AND SLIMES.

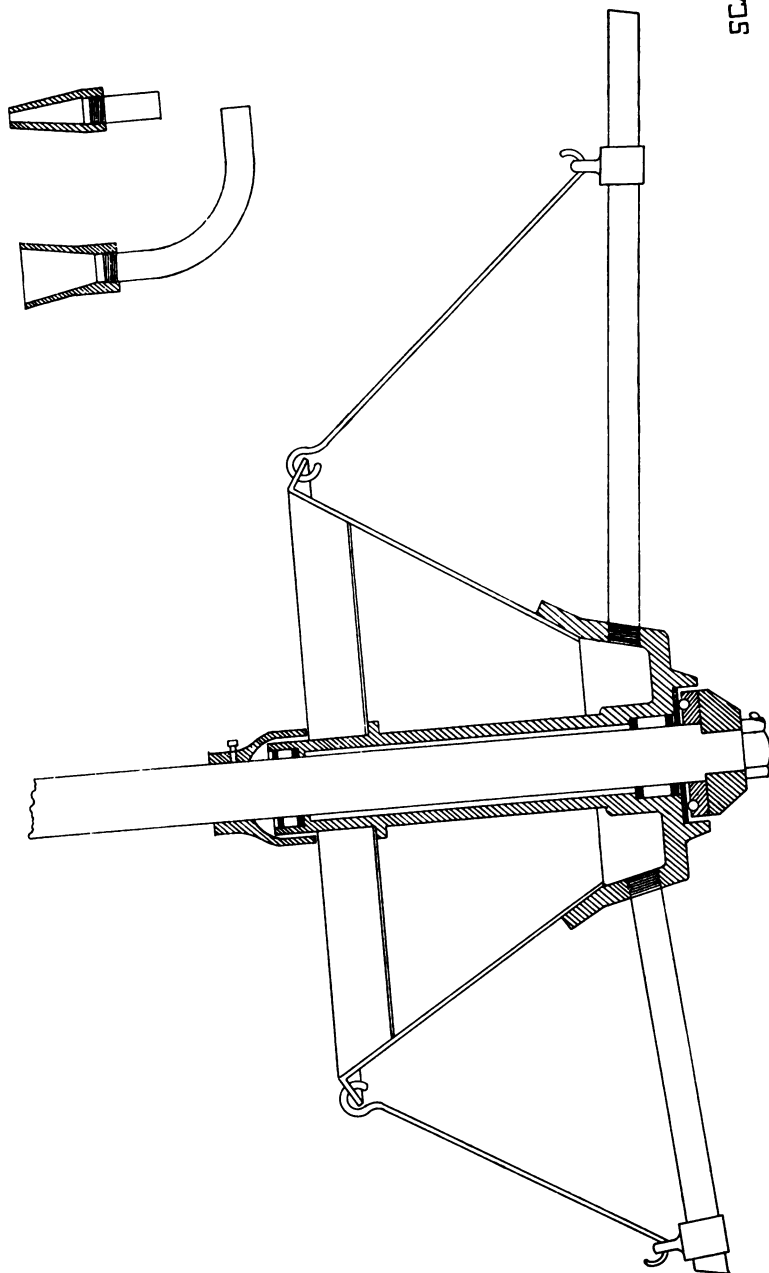
Sands at the Dakota mill constituting 70 per cent of the mill product.	Slimes at the Dakota mill constituting 30 per cent of the mill product.
On a 20 mesh screen 13 to 20 per cent.	On a 100 mesh screen 0.3 to 0.4 per cent.
" " 40 " " 30 " "	
" " 80 " " 26 " 54 " "	On a 150 mesh screen 12 to 33 per cent.
" " 100 " " 7 " 8 " "	Passed a 150 mesh. 60 to 87 " "
" " 150 " " 13 " 18 " "	
Passed a 150 mesh 4 " 5 " "	
Sands at the Lundborg, Dorr* and Wilson mill, constituting 50 per cent of the mill product.	Slimes at the same mill, constituting 50 per cent of the mill product.
On a 40 mesh screen 30 per cent.	On a 60 mesh screen 0.5 per cent.
" " 100 " " 40 " "	" " 100 " " 1.5 " "
" " 200 " " 24 " "	" " 200 " " 18 " "
Passed a 200 mesh 6 " "	Passed a 200 mesh screen 80 " "

It may be noted that a comparison of these products at the different mills is not possible as the ores differ and what is a fine sand at one mill according to mesh size may be a slime at another.

The proper separation of the sands from the slimes is a vital question to be solved with the plants of the Black Hills and is one that has given the mill men much trouble. While the present system is a great improvement on the practice of the earlier mills there is still much room for further improvement.

THE TREATMENT OF THE SANDS.—The filling of the sand tanks is accomplished by distributors of the Butters and and Mein type, the construction of which is shown in some detail in the accompanying plate. The distributor is suspended from a trolley running on tracks above the sand vats, so that the distributor can readily be transferred from one vat to the other. The sands are fed into the hopper of the distributor by a launder, which feeds as near the center of the hopper as possible, avoiding the throwing of the feed against the sides as this causes an irregular distribution of the sands in the vat. The dimensions of the distributors vary according to the capacity required. The slope of the pipe arms is 1 in 12, and the diameter of the pipes varies in the different distributors from 1.5 to 2.5 inches. Generally all the pipe arms in a distributor are of the same diameter, but in the one at the Horseshoe mill the long arms are 3.5 inches, the medium arms are 2.5 to 3 inches and the short arms 2 inches in diameter. The discharge nozzles are usually separate castings, the discharge being controlled by wooden

* This mill has replaced cone classifiers, by a mechanical classifier, the invention of Mr. J. V. N. Dorr.



SCALE 1:10

Distributor for Sandoz.



plugs. The number of arms is generally six, although the distributor at the Horseshoe mill has 8 arms. In the case of one of the six arm distributors the following figures give the length of arms. 13.25 feet, 11.5 feet, 9.5 feet, 8.0 feet, 5.5 feet and 2.5 feet. These arms are unsymmetrically hung in such a way that their weight balances the distributor. The discharge of the pipe arms must cover the surface of the vat. The hoppers of the distributors are provided with a horizontal screen to keep foreign matter out of the pipe arms. The function of the distributors in the mills crushing siliceous ore is not in part that of a classifier acting with a filled vat in removing slimes from sands, but it acts solely to evenly distribute sand in the vats. The sands are not laid down under water or solution, but the vat is what might be called dry filled, the solution which goes into the vats continually draining off through the filter until the vat is full of sands. The top layer of sands in the vat is always practically dry. This method of filling has the advantage, first, that the slimes in the pulp are uniformly distributed with the sands in the vat, which is not the case when direct filling is employed under water; second, that for this reason it gives a charge that is more percolable, and third, that during the filling a great amount of solution passes through the sands, in this way treatment going on all the time that the vat is filling. The charge laid down in this way is also more porous than when laid down under water. At the Maitland mill the amount of solution passing through a 150 ton charge of sands while filling is 700 tons, or 4.7 tons of solution per ton of sands.

The time of filling a 30 by 6 foot vat at the Maitland mill is 60 hours; at the Lundborg, Dorr & Wilson mill a vat, 18 by 10 feet is filled in 60 to 72 hours. At the Dakota mill a 115 ton vat is filled in 38 hours.

The method of filling formerly employed at the first wet crushing plants of the Hills, the Portland and the Dakota Mills, was the indirect method, settling boxes with two compartments being used, these compartments alternately discharging their contents into the sand vats below, where the charges were raked over and leveled off. At the Dakota mill double treatment of the sands was also resorted to, but discarded as unnecessary after a year's trial. The settling boxes were found to be such inefficient classifiers that the cone system described was evolved and the sands charged at some of the mills, by distributors into the sand vats filled with solution. All of the plants however soon adopted the method of "dry filling" described as

more satisfactory.

The general method of the treatment of the sands is the same at all of the mills although the amount of solutions and the time of treatment varies. The treatment of the sands is determined as far as extraction will permit by the problem of handling the mill solutions, which in a plant of the type under discussion is quite complex as might be expected.

The following table shows some of the details of sand treatment:

Name of Mill.	Capacity of Tank.	Amount of solution passing while filling.	Amount of Battery Solution.	Amount of Barren Solution.	Amount of Wash Water	Total Time. Days.
Maitland.....	140 tons	700 tons	900 tons	450 tons	15 tons	16
Dakota.....	115 tons	86 tons		63 tons	20 tons	5
Horseshoe.....	350 tons	400 tons				8

Solutions are leaching through the sands continually, there being no "contact" or solution standing on the ore as in dry crushing mills. There is also no strong solution properly so called, although the battery solution and the barren solution differ slightly in strength, in some mills the barren solution being the stronger while in others the battery solution is the stronger. At the Maitland mill the battery solution carries 1.20 to 1.30 pounds of cyanide per ton, and the barren solution 1.50 to 1.60 pounds per ton. At the Horseshoe mill the battery solution carries 1.4 pound of cyanide per ton and the barren solution is somewhat stronger, though of indefinite strength. At the Horseshoe mill, the overflow solution from the slimes vats while these are filling, is standardized in a sump tank up to three to four pounds of cyanide and then run through the sands. At the Dakota mill the battery solution contains 2.2 pounds of cyanide per ton, and the barren solution two pounds per ton. At the Lundborg, Dorr & Wilson mill the battery solution contains two pounds of cyanide per ton and at the Hidden Fortune mill it contains 1.3 pounds per ton. The amount of wash water varies but little at the different mills amounting to 0.1 to 0.2 tons per ton of sand. Little wash water is required as the cyanide solutions are all weak and such large amounts of solution are passed through the sands in most of the mills. The deficit of solutions in the



Sand Vats, Mogul Mill, Horseshoe Mining Company.

mills is made up mainly from wash water added in the slimes treatment.

The following figures show the result on sands obtained at the Dakota mill, over a period of 5.50 months: The average value of the ore was \$4.75 per ton. The sand tailings averaged \$1.22 per ton. This gives an extraction of 74.25 per cent on the sands. The moisture going out with the sand tailings had a value of 40 cents per ton. During May, 1904, the average value of the ore was \$4.55 per ton. The average value of the sand heads as charged into the vats was \$2.60 per ton, the average value of the sand tails unwashed was \$1.06 per ton giving an extraction of 76.7 per cent on the sands. Comparing the original value of the ore, the sand heads and the sand tails, it is evident that 42.8 per cent of the extraction takes place in the batteries and cones, and 33.9 per cent during the sand treatment proper.

At the Hidden Fortune mill the extraction on the sands averages 75 per cent. For the extraction on the slimes and the total extraction reference is made to the figures given under slimes treatment.

THE TREATMENT OF THE SLIMES BY AGITATION AND DECONTAMINATION.—There are two systems of slimes treatment practiced in the Hills.

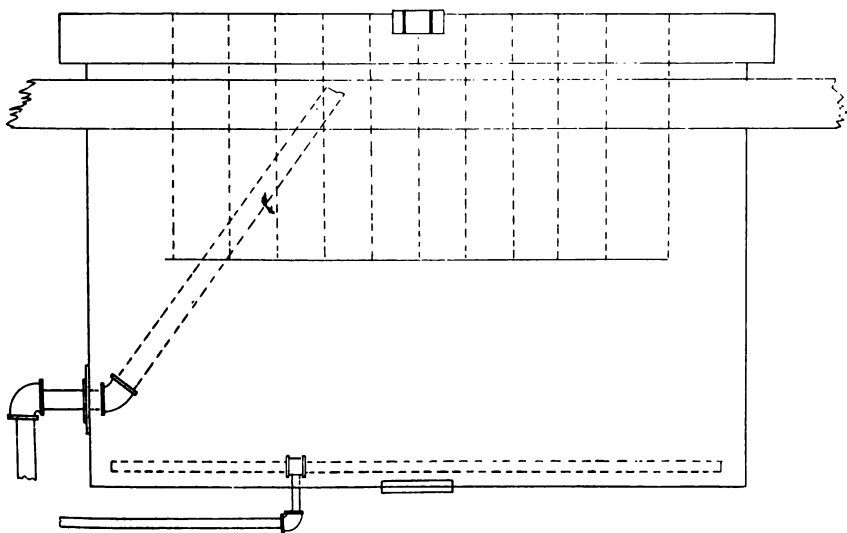
1. That in which the treatment of the slimes is completed in the vat into which they are originally charged, and in which most of the agitation is performed by compressed air.

2. That in which the slimes are successively transferred from one vat to another, there being generally three to four transfers before the slimes are discharged. The agitation in this case is done by means of centrifugal pumps.

The first method is practiced at the Horseshoe mill as follows: there are 16 slimes tanks, 14 feet in diameter and 10 feet deep and two 30 feet diameter and 10 feet deep. The arrangement of a slimes tank as shown in the accompanying plate. A partition curtain runs down to nearly the bottom at one side of the tank behind which the slimes are charged as they come from the cones. Before charging slimes the vat is filled with barren solution, then the slimes are run in, the surplus solution running off clear at the lip, any foam being held back by a strip of wood or lath resting on the surface of the solution. Four to six pounds of lime are added per ton of ore at the batteries for the coagulation of the slimes, this being the only addition of lime made in the mill. The addition of lime must be some-

what nicely adjusted as too little lime fails to coagulate the slimes readily and too much gives trouble in the precipitation of the values later on. The slimes settle rapidly and the solution usually runs off clear at the lip until the slimes have accumulated to the extent of about 50 inches, equivalent to about 25 to 30 tons of dry slimes. When the solution at the lip becomes cloudy the slimes charge is turned into the next tank and the slimes in the tank just filled are permitted to settle. This settling takes about ten hours. While the slimes are settling the supernatant solution is decanted off by means of a decanting device which is a simple wooden frame with a pipe at the center which is connected with a take-off pipe about 18 inches from the bottom of the vat. (See plate.) It is important to permit the slimes to settle as low as they possibly can and to decant as closely as possible without taking any of the muddy solution. The object of the slimes treatment in the main is to remove by successive dilutions the dissolved values, so that it is evident, unless the decantation is as close as possible each time, it partly fails in its object. The solution can usually be decanted within an inch of the settled slimes. When the decantation is complete a wash of barren solution is added, amounting generally to 40 tons and during the addition of this the charge is agitated by compressed air at 40 pounds pressure per square inch. The air is introduced on the bottom of the vat through two S shaped pipes crossing each other, and having 0.12 inch perforations. The only agitation the slimes receive is that obtained by the air. The agitation by air alone is a weak point in that it fails to move all of the material, especially the heavier portion of the slimes and the fine sands at the bottom of the vat. For that reason on discharging a vat, it is not sluiced out, but what slimes will run out by the bottom gates are let go, and the heavy thick slimes remaining, amounting to two to four tons per charge, form again a portion of the next charge thus getting two treatments. Each charge of slimes gets four to six washes with barren solution and one wash with water, each wash amounting to 40 tons. This gives 6.5 tons of barren solution and 1 to 1.6 tons of wash water for each ton of dry slimes treated.

The slimes as discharged contain very close to 50 per cent moisture. From ore averaging \$8 to \$9 per ton dried slimes tailings average \$1.75 per ton, 30 to 40 per cent of which still existed as gold in solution. This gives the washed slimes tail-



SCALE 1:50.

1. The first part of the document is a list of the names of the persons who were present at the meeting.

2.

ings a value of \$1.24 per ton and the solution discharged as moisture, a value of 50 cents per ton.

In the treatment of slimes by successive dilutions for the extraction of the values where, in the total treatment a definite amount of solution is used per ton of dry slimes, it is theoretically required, in order to get the maxim extraction, to use the amount of solution in a comparatively large number of dilutions of small amount each time, rather than a few dilutions of large amount each time. Thus, in treating a ton of slimes with six tons of solution, it is theoretically better to give six dilutions of one ton each, rather than two dilutions of three tons each. If any one dilution is larger than the other it should, of course, be applied when the slimes are highest in value. It must be borne in mind however, that in the slimes treatment there is a solution of values constantly going on during the treatment so that while the solution is being reduced in value by dilution it is constantly being augmented by the solution of new values, so that the solution finally discharged as moisture with the slimes tails will never be as low in value as the dilution calls for. Since the cost of applying a dilution of definite quantity to the slimes is the same, no matter what the value extracted by the dilution is, it will be seen that the economic limit is soon reached where further dilution will not pay. Few of the mills can afford to apply more than four to five dilutions profitably. It must also be borne in mind that with an increased number of dilutions the amount of solutions to be handled in the mill will increase. As it is, at present the mill handles a great quantity of solution per day. The application of an extra water wash to the slimes would, however, not be so objectionable if the decantations from the last wash were run to waste through a large zinc box in which the poorer grade of shavings and the dust from the lathe could be utilized. The saving made in this way would probably be appreciable.

The treatment of the slimes at the Hidden Fortune mill is similar, but differs in details. The slimes vats are first filled with barren solution and the slimes pulp is charged at the center of the vat through a large pipe which leads to within a few feet of the bottom of the vat. The clear solution overflows continually around the whole of the periphery being collected by an annular launder and taken to the battery sumps. When the outgoing solution becomes cloudy the charging of the slimes is stopped and slimes are permitted to settle the clear solution at

the top, in the mean-time being decanted to the battery sump, in a similar way described for the Horseshoe mill. When the solution has been decanted to within an inch or two of the slimes the top layer of thin slimes, to a depth of three or four inches, is pumped to the vat that is filling with slimes, the object of this being to remove as much solution as possible in order to have the next dilution as efficient as possible. The first wash of barren solution is then added, this being added through the perforated air pipes at the bottom of the vat. This method of adding the barren solution is adopted, first, to keep the perforations of the air pipes clear, and second, to secure the agitation and moving of the heavier slimes at the bottom of the vat. After the addition of barren solution the charge of slimes is agitated with air at 40 pounds pressure per square inch, then permitted to settle and the clear solution decanted as described.

The slimes receive three washes with barren solution and one with water. Before the slimes are finally discharged the top layer, to a depth of three or four inches, is again pumped to the vat which is filling. The total time required for the treatment of the slimes is between three and four days. Three washes are found sufficient at the Hidden Fortune mill since the slimes receive an unwatering before going to the slimes vats, as has been described. At this mill the extraction made on slimes as determined by the assays on the washed tailings is 80 per cent. The actual recovery is but 75 per cent, as determined by the unwashed tailings, showing a loss of gold of five per cent which goes out with the slimes tailings in the dissolved form.

The second method of treatment in which the slimes are successively transferred from one vat to another is illustrated by the practice at the Dakota mill. The slimes from the cones are alternately charged into the loading vats, No's. 1 and 2, which are 20 feet in diameter and 137 inches deep. Each vat is filled for twelve hours then permitted to settle for ten hours, the clear solution at the top being continually decanted off, finally to within one inch of the settled slimes. The settled slimes are then pumped by a centrifugal pump having a four inch suction to vat No. 3, barren solution being continually added to the suction of the pump during the transference which takes from one to three hours. In vat No. 3 the slimes are permitted to settle again for ten hours, the clear supernatant solution being decanted off meanwhile. The slimes are then transferred to vat No. 4 by the pump, barren solution being added to the suction. In vat No. 4 the slimes receive an additional agitation by pump-

ing for about one hour, the slimes being drawn off at the bottom of the vat by the pump and returned over the top. The settling and decanting is then repeated and the slimes transferred to vat No. 5. From this vat after the settling and the decantation of solution the slimes are transferred to vat No. 6, but this time with wash water instead of barren solution. The amount of wash water added is equivalent to the amount of moisture in the slimes. In vat No. 6 the last settling takes place, the solution is decanted and the slimes are discharged. Lime for the coagulation of the slimes is added to the extent of six pounds per ton of ore at the batteries. The time required for the treatment of the slimes is five days.

The following figures on slimes treatment at the Dakota mill are of considerable interest: In 5.5 months 6,681.67 tons of slimes were treated, the slimes amounting to 33 per cent of the ores crushed. The average value of ore during this period was \$4.75 per ton. The slimes tailings dried and unwashed assayed \$1.31 per ton, giving a recovery on the slimes of 72.28 per cent. The washed slimes tailings assayed \$0.912, showing a solution of the values of 80.7 per cent and a loss of soluble gold of 40 cents per ton or 8.42 per cent of the value of the ore. The slimes are discharged with 50 per cent moisture, this moisture consisting of solution having a strength of 1.07 pounds of cyanide per ton. Since there is a ton of this solution going to waste for every ton of dry slimes discharged, in the 5.5 months which the above period covers, there were lost 7,147.6 pounds of cyanide which, at 23 cents per pound had a value of \$1,644. Adding to this the loss in dissolved gold amounting to \$2,672, the total loss is \$4,316, or 64 cents per ton.

These figures show clearly the weak points of the decantation system of slimes treatment. The Dakota Mill is one of the most successful mills in the district, treating what is practically the lowest grade of siliceous ores handled in the district. The results on sands at this mill are discussed under sand treatment. The treatment of the slimes at the Maitland Mill is similar to that at the Dakota. Each ton of dry slimes receives a treatment by 5.38 tons of barren solution and 0.96 tons of wash water. The solution going out with the slimes as moisture contain \$0.46 in gold per ton. The head slimes solution or the solution first decanted from the slimes while filling has a value of about \$2.00 per ton.

At the Lundborg, Dorr & Wilson mill the Moore slimes process is used on the slimes. There are three rectangular vats 15 feet long, 7 feet wide and 5.5 feet deep. The first tank has a double hopper bottom, the sides inclined at 45 degrees to more readily collect the heavy slimes which sometimes fail to be taken on the filter frames. There is a set of 35 frames 4.5 by 6 feet in area and made of two inch material. The filtering medium is 18 ounce duck. Both sides of the frames are effective as filters and the total filtering area is 1836 square feet. The interior of the frames are connected with a pump which produces suction and also with a compressor. The suction is equivalent to 18 inches of mercury. The set of frames is suspended from a hydraulic crane which transfers the frames from one vat to the other. The method of treatment is as follows: The slimes after agitation by air and a centrifugal pump in an eight foot sheet iron cone are run to the first tank of the Moore process, the frames are immersed in the slimes and the suction is started. A coating of slimes deposits on the filters and the clear solution is discharged by the pump. When the slimes layer on the filters has accumulated to the thickness of an inch, which amounts to a load of four tons on the set of frames, and takes from 40 to 65 minutes, the frames are lifted out with their adherent load of slimes, suction meanwhile being continued, and immersed in the next vat which is filled with barren solution. This barren solution is sucked through the slimes for 40 minutes, when the frames are transferred to the next vat which is filled with water. This water is sucked through the slimes for 40 minutes, when the frames are lifted out, transferred to above the discharge hopper, the suction changed to pressure, which causes the slimes to peel off into cars below the hopper. Some little scraping has to be done to clean the frames. No figures are as yet available concerning the results of the Moore process, permitting of a comparison with the decantation process. It is a fact however that the process discharges dryer slimes, those at the Lundborg, Dorr & Wilson mill containing from 34 to 36 per cent moisture, as against 50 per cent, which is the usual figure for the decantation process. At the mills where the upper layer of slimes is pumped off as described for the Hidden Fortune mill the slimes are discharged with 40 to 47 per cent moisture. Some of the mills of the district which must confine their tailings within narrow limits and cannot let them flow freely to waste, experience considerable trouble from the high moisture contents of their slimes tail-

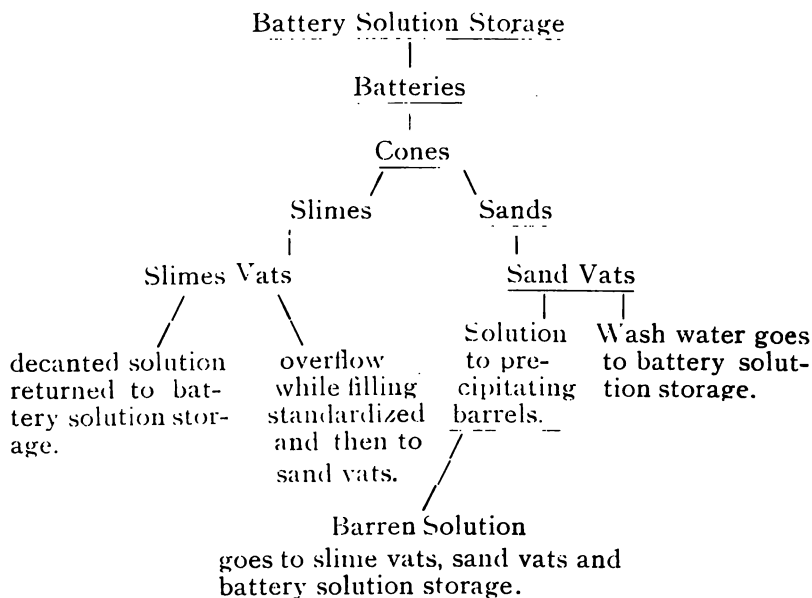


Filter Frames, Moore Slimes Process.

ings. The slimes tailings from the Moore process are much more easily held in check. In making a general comparison between the Moore and the decantation process it must be borne in mind that the slimes are under treatment in the Moore process only two to three hours, and in that time receive practically no agitation, so that the solution of the gold must take place practically before the slimes go to the Moore process. The Moore process, even with separate agitation however shortens the time on the slimes materially and a large capacity can be installed within a small space.

Filter press experiments have been made on a fair sized scale at one of the mills in the district, which indicated that slimes could be made containing about 25 per cent moisture and that these slimes, on account of the close washing feasible, carried very little cyanide and dissolved gold. It would not be surprising to eventually see filter pressing replace the decantation process at least in part.

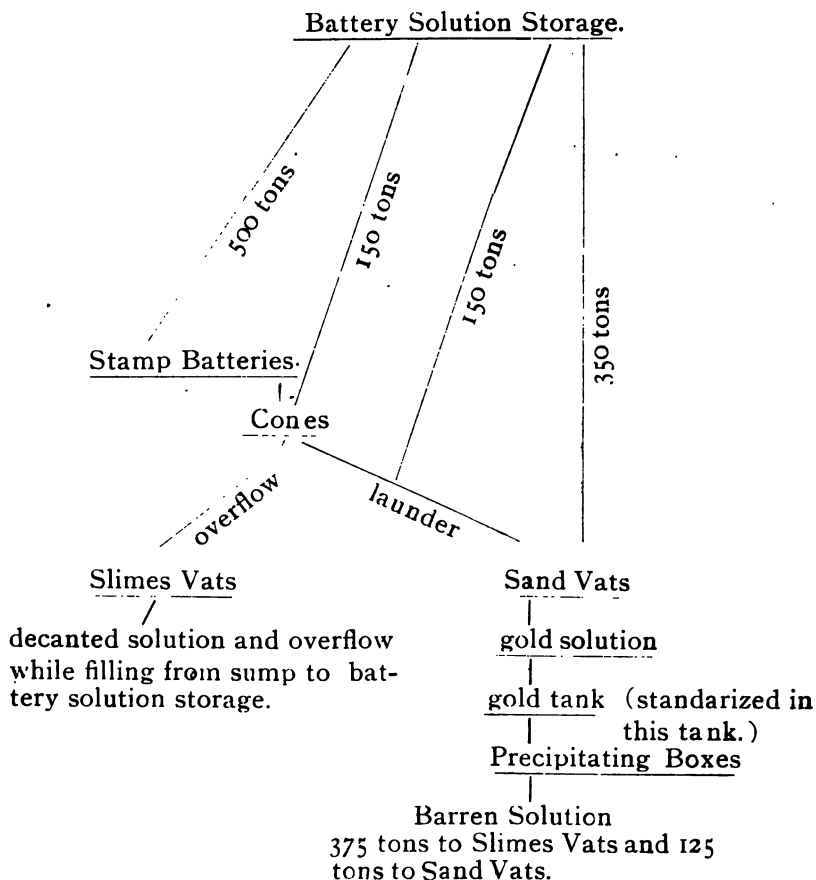
THE DISTRIBUTION OF SOLUTIONS IN THE MILLS.--The distribution of solutions in the mills is quite complex, and the following diagrams show the general practice. Distribution of solutions at the Horseshoe mill.



It will be noticed that the only solution going to the precipitating boxes is that which has passed the sands. This amounts

to from 300 to 1,000 tons per day. The battery solution has a gold value of approximately one dollar per ton. This value is derived for the greater part from the decanted slimes solution. The cyanide needed to bring up the strength of the solution is added to a comparatively small amount of decanted slimes solution, more particularly the overflow solution from the slimes vats while these are filling. This is brought up to three to four pounds of cyanide per ton and run on the sands so that these get the benefit of what is practically a strong solution.

In the scheme of the Maitland mill which follows, it will again be noticed that the only solution that is precipitated is that which has passed the sands. This is the general practice at all of the mills. The solution is restandardized ahead of the zinc boxes in order to get more efficient precipitation as there is some copper in the solution. The strength of the various solutions at the different mills is given under the discussion of the treatment of the sands. The battery solution in the case of the Maitland mill has a value of about 50 cents of gold per ton and the barren solution about ten cents per ton. About 1,100 tons of battery solution are pumped per day and close to 500 tons of solution are precipitated every day, which, after precipitation, becomes the barren solution, so that the mill handles per day about 1,600 tons of solution, which, with a capacity of 120 tons of ore per day, is 13.1 tons of solution per ton of ore. The pumping expense of a wet crushing mill per day is appreciable and in the design of a mill the question of handling the solutions is a very important one. At one of the mills the restandardization takes place in the battery sump so that the strongest solution is used in the battery. This practice is for obvious reasons not the best.

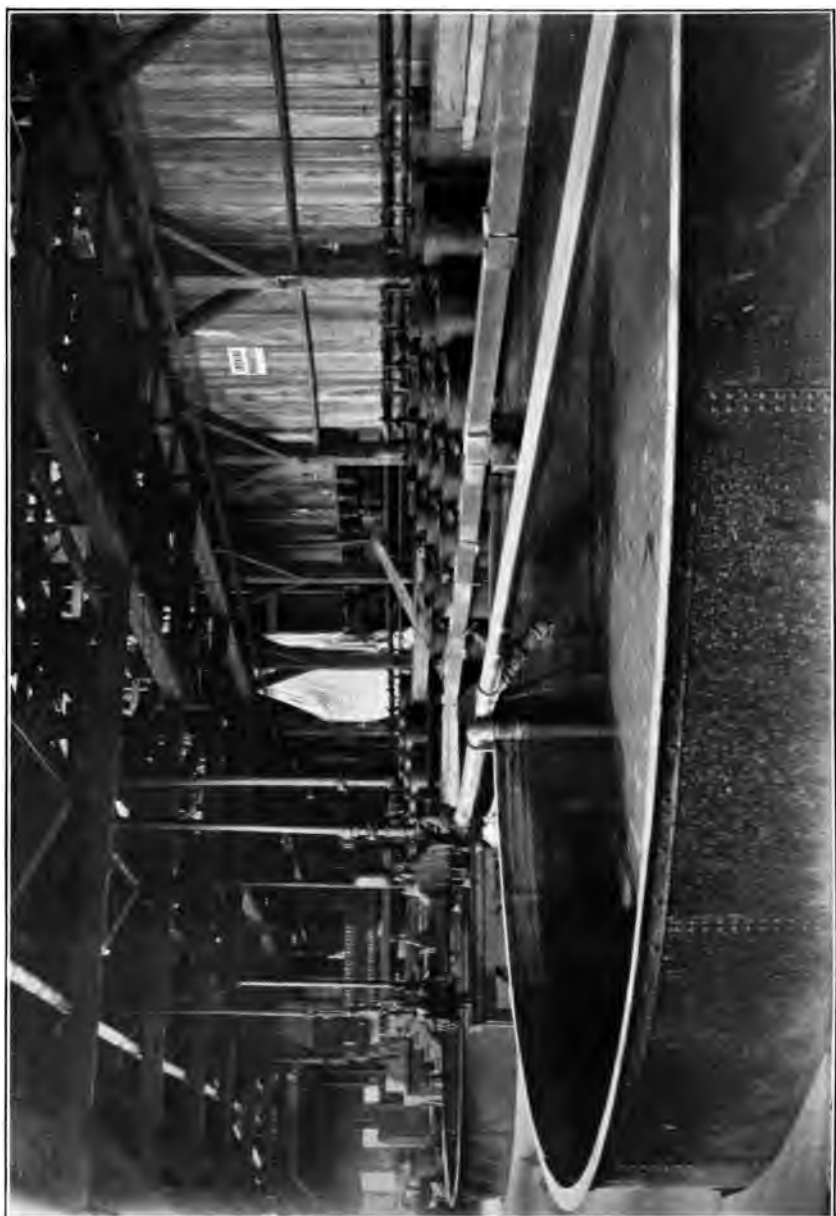
Distribution of Solutions at the Maitland Mill.

THE PRECIPITATION OF THE VALUES.—In general no troubles in precipitation are encountered in the form the process is employed at the present time. In the earlier practice of the mills when decanted slimes solution was passed through the zinc boxes with the idea of keeping the battery solution practically free from gold values trouble was experienced by getting a very bulky and low grade precipitate on account of the accumulation of fine ore slimes in the boxes, but in the present practice this trouble is avoided as described. At the Dakota and Horseshoe mills precipitation is carried on in barrels. These at the Horseshoe mill are two feet in diameter and two feet high, holding five cubic feet of zinc, or 25 pounds. 120 of those barrels are in use. The barrels can readily be taken up on

a pulley gear running on a trolley and conveyed to the clean-up tank for discharge and cleaning. At the Horseshoe mill where 225 to 250 tons of ore are treated per day, 1,000 tons of solution are precipitated every 24 hours. The zinc consumption is one pound per ton of ore treated. At the Dakota Mill it is 0.58 pounds. At the Hidden Fortune and the Maitland mills precipitation is carried on in the usual form of iron zinc boxes. At the Maitland Mill treating 120 tons per day there are four boxes of eight compartments each, the compartment having a capacity of seven cubic feet of zinc. From 450 to 500 tons of solution are precipitated per day, there being 2.13 tons of solution for each cubic foot of zinc. The solution entering the boxes is kept at 2.5 pounds of cyanide per ton, for a lower tenor causes trouble by copper precipitating, which the solutions carry to a small extent. The zinc consumption is 0.3 of a pound per ton of solution precipitated and 1.33 pounds per ton of ore treated.

TREATMENT OF THE PRECIPITATES.—The precipitates are refined at all of the mills by the usual sulphuric acid method into bullion which is disposed of to the United States Assay Office at Deadwood. The fineness of bullion varies at the different mills as the silver contents of the ores vary considerably. However, at most of the mills the bullion produced ranges between 450 and 600 fine in gold. In order to dispose of the bullion to the Government Assay Office at Deadwood, the bullion must have a minimum fineness of 600 in gold and at some of the mills in the smelting of the precipitates a matte is purposely formed so that the resulting bullion will be above the minimum limit. The slags from the smelting of the precipitates are disposed of to the smelters at Denver, although at the Horseshoe Mill the slags and matte from the smeltings are refined by melting with litharge and cupelling the resultant bullion.

GENERAL EXTRACTION FIGURES.—The extraction at the mills varies from 68 to 75 per cent, according to the ores treated. At the Maitland Mill where the extraction is 73.2 per cent and where approximately half the ore is treated as slimes and half as sands the extraction is distributed as follows, 39 per cent is extracted in the batteries and cones, 16.5 per cent in the slime treatment, and 17 per cent in the sand treatment. As a general thing the recovery of bullion is either two to three per cent higher or the same amount lower than the assays of the ores, tailings and solutions call for.



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THE COST OF TREATMENT.

The following is the detailed cost of treatment at the Dakota Mill during a period in 1902. The average value of the ore was \$4.70 per ton.

Labor.....	45.3c
Superintendence.....	9.0
Cyanide.....	21.1
Zinc.....	3.3
Lime.....	1.2
Power.....	22.6
Shoes, dies, etc.....	9.5
Repairs.....	2.7
Refining.....	3.
Assay Office.....	4.
General Expense.....	5.0

Total.....127.7 \$1.27 per ton.

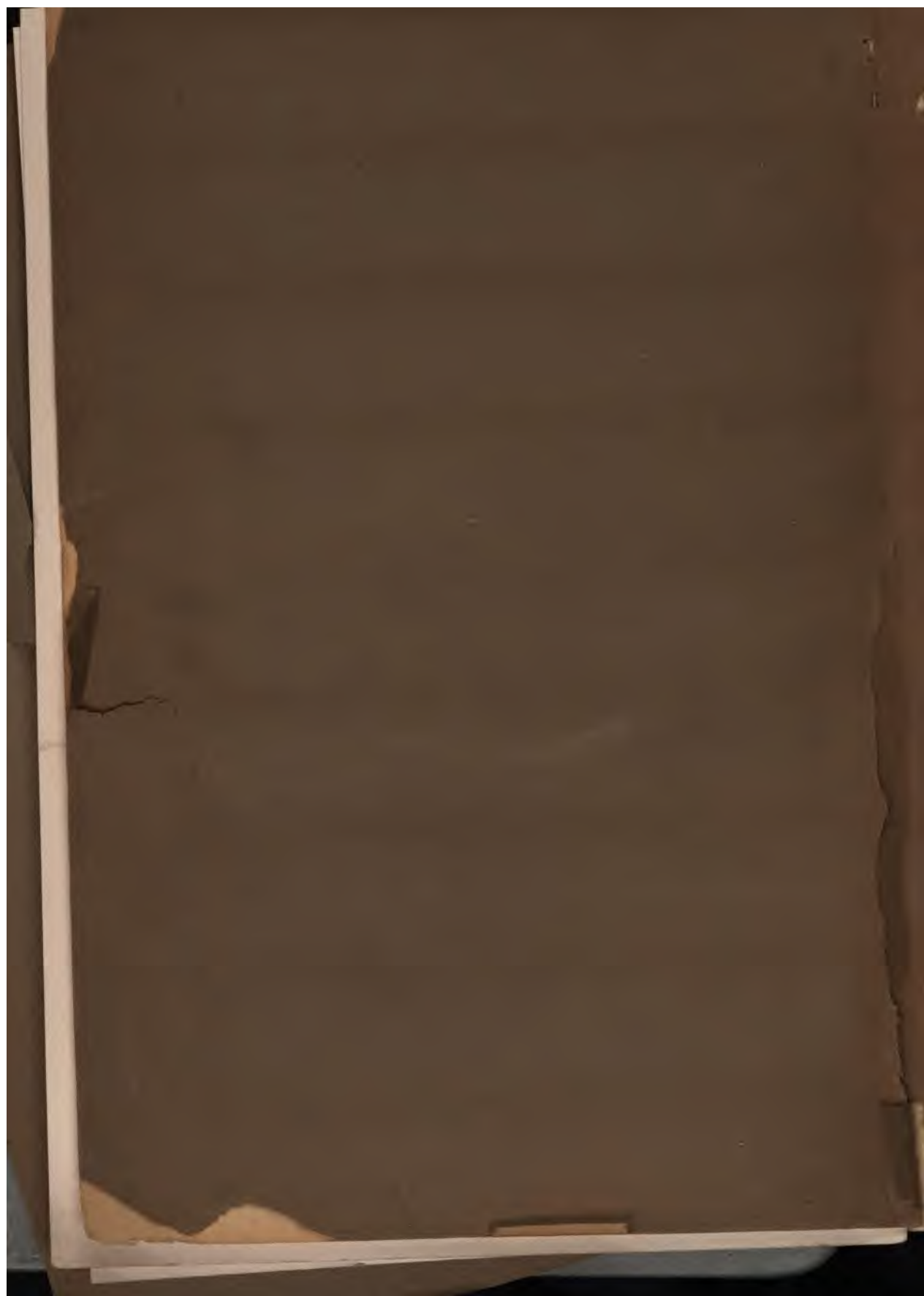
The mill during this period treated 100 tons per day. The cost at the Dakota Mill, at the present time owing to a somewhat increased capacity has been reduced to \$1.17 per ton.

The cost at the Maitland Mill treating about 125 per ton per day, and which is not situated on the railroad so that the cost of supplies is considerably increased, is \$1.79 per ton. The cost at the other mills ranges between the costs at the two mills given.

NOTE. This paper is printed in advance, by permission, from the T. A. I. M. E., September 1904.

NOTE. The author wishes to acknowledge his indebtedness for much information contained in the above paper to Mr. John Gross of the Maitland Mill, to Mr. John Ingersol of the Dakota Mill, Mr. J. V. N. Dorr, of the Lundborg, Dorr & Wilson Mill, to Mr. Freeman Steele of the Hidden Fortune Mill and to Mr. G. H. Clevenger of the Horseshoe Mill.







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BULLETIN NO. 8

South Dakota School of Mines

Departments of Geology, Chemistry, Mining
and Metallurgy.

THE

Cement Resources

OF THE

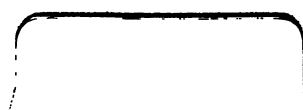
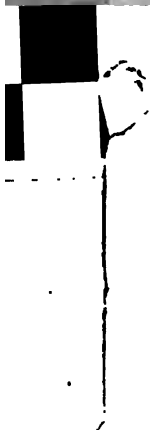
Black Hills.

Including Tests on
Cements Made from Black Hills Material. *

BY

CLEOPHAS C. O'HARRA, Ph. D.
M. F. COOLBAUGH, M. A.
M. A. EHLE, Jr. E. M.
CHAS. H. FULTON, E. M.

RAPID CITY, S. D.
JULY, 1908.





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Rapid City Printing Company,
Rapid City, S. D.

Letters of Transmittal.

SOUTH DAKOTA SCHOOL OF MINES.

Rapid City , S. D., July 1, 1908.

Dear Sir:—

I have the honor to transmit herewith a paper by C. C. O'Harra, M. F. Coolbaugh, Mark Ehle and C. H. Fulton on the Cement Resources of the Black Hills of South Dakota. I submit it with the recommendation that it be published as Bulletin No. 8 of the School of Mines.

Respectfully,
CHARLES H. FULTON,
President.

To The Hon. E. C. Ericson, President,
Regents of Education.









Introduction.

The great increase in the use of Portland Cement has drawn attention to possible sources of raw material. The Black Hills of South Dakota are especially favored in this respect, both as regards the quantity available, and the purity of the material. In the experimental work on the cements care was taken to have it thorough and representative. Much more work was done than is recorded in the bulletin.

The editor desires to express thanks to Mr. William A. Coursen for the efficient aid given in the construction and operation of the experimental cement furnace; also to thank Mr. J. B. Read for services in connection with the making of analysis, etc. The editor also expresses his gratitude to his colleagues, Professors O'Harra, Coolbaugh and Ehle for their able labors in making this bulletin thorough and representative.

CHARLES H. FULTON,

Editor.



PART I.

THE GEOLOGY OF THE BLACK HILLS CEMENT
MATERIAL.

C. C. O'HARRA, Ph. D.





The Geology of Black Hills Cement Material.

C. C. O'HARRA, PH. D.

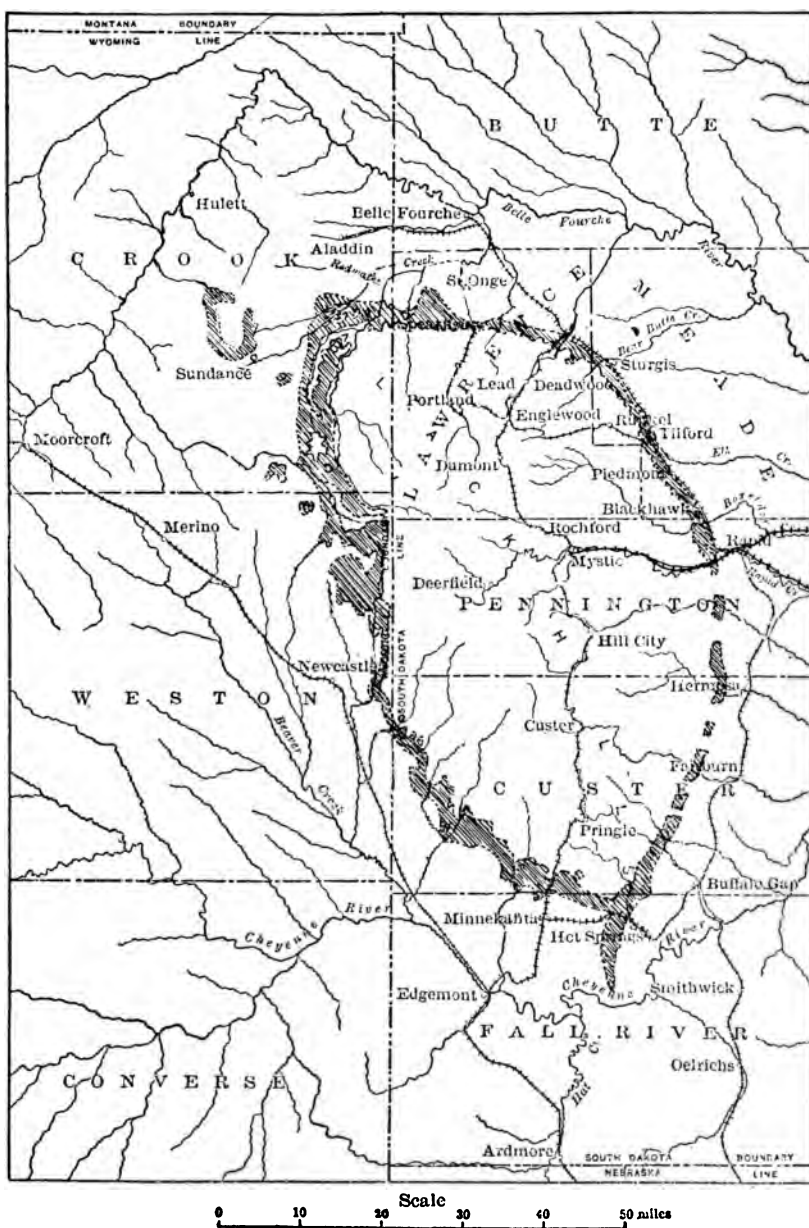
The Black Hills region is bountifully supplied with deposits available for the manufacture of good cement. Until recently little attention has been given to the experimental study of these materials and in this bulletin chief attention is directed toward the examinations of two or three formations of special promise favorably situated with reference to railroads.

The formations chiefly studied are what in geologic literature are known as the Minnekahta limestone, the Graneros shale, and the Niobrara argillaceous chalk. Experimental work indicated that by a proper mixture of materials from the Minnekahta and the Graneros formations a compound can be made, suited in every way for the manufacture of a high grade Portland cement, while the Niobrara can furnish material of proper composition for the making of excellent natural cement. Of the limestones, the Minnekahta is the only one of the region deemed worthy of consideration at this time. The Pahasapa is the great limestone formation of the Black Hills, making long lines of high white escarpment facing on all sides the central part of the uplift, but it contains much magnesia and too little attention has been paid to the possible magnesia-free portions to allow for any reliable statement as to favorable localities where this limestone might be profitably exploited. Such other limestones as occur within the region are thin or impure and are often inclined to considerable

variation in character, hence have not been given special attention.

The shale-bearing formations are abundantly represented and several of them give evidence of possible value used in combination with the Minnekahta limestone. In addition to the Graneros already mentioned there are the Pierre, the Niobrara, the Carlile, the Morrison, and possibly other formations that merit careful examination, should an exhaustive study be made of all available materials. That the geologic position of the various formations may be better understood a complete generalized geologic section of the Black Hills region is here given.

The Minnekahta Limestone. The Minnekahta limestone, known commonly in early geological papers as the Purple Limestone, although seldom more than fifty feet in thickness is one of the prominent outcropping formations of the Black Hills region. It is a close-textured, thinly-bedded, grayish limestone with frequently a slight pinkish or more often a purplish tinge, hence the earlier name. The bedded nature of the rock is much concealed on fresh surfaces, but weathering reveals the condition in a very definite way. Near the middle of the formation the nature of the bedding is such as to allow for slightly more rapid weathering than elsewhere and this feature generally reveals itself in unmistakable manner. Near the bottom the bedded nature is again pronounced and the rock here contains considerable argillaceous material. The lowest beds which are generally much ironstained are not commonly exposed. In some localities where they are exposed the limestone breaks up into numerous small lenticular concretionary bodies within which fairly well-preserved fossils are found. In general, however, the formation is markedly free from fossils, although not quite so much so as was earlier supposed. Mr. N. H. Darton of the United States Geological Survey records the identification of *Bakewellia*, *Edmondia*, and *Nuculana*.



Map showing outcrop of the Minnekahta formation



The Minnekahta is underlain by a thin series of soft clay shales known as the Opeche formation and is overlain by a thicker series of soft sandy shales, the Spearfish formation, commonly known as the Red Beds. The dip, sometimes steep, sometimes low, varies in a more or less undulatory manner, but in general it follows the nature of all of the periclinal sedimentary rocks of the region in that it is distinctly apocentral, that is, it dips outwardly on all sides from the higher central portion of the main Balck Mills uplift.

The outcrops are unusually prominent everywhere. The relatively hard, more or less sharply dipping limestone between the soft shale beds readily lends itself to the production of a bold topography. Hundreds of streams, constant and intermittent flowing radially from the central area of the uplift run across the formation and each carves for itself a V-shaped gateway to the red valley beyond. On the outer slopes wherever the dip is considerable, the rock is nearly bare of soil and vegetation although the pine trees, *Pinus ponderosa*, cling tenaciously to it wherever a foothold can be secured. The inner line of outcrops is a continuous succession of prominent escarpments which, facing the central area of the uplift dome, stand out in bold relief as they overlook the sharply, trenched Opeche below.

The width of outcrop varies greatly. Where the dip is steep as for example along Beaver creek and the lower portion of Gillette canyon east of Newcastle and on the immediate flanks of several of the lacolithic areas which interrupt the general foothill structure, the width of the outcrop is reduced to a minimum. Elsewhere where the dip is slight and gently undulating, such as in the southern Hills west and northwest of Hot Springs, in the northern Hills near Spearfish and still better, along the western side of Cold Spring creek in Wyoming extensive areas are capped by this limestone. Local irregular and isolated

FORMATION	CHARACTER	AVERAGE THICKNESS FEET	AGE
Laramie.....	Massive Sandstone and Shale.....	2,500	Tertiary and Pleistocene Oretaceous
Fox Hills.....	Sandstone and Shale...	250-500	
Pierre Shale....	Dark Gray Shale.....	1,200	
Niobrara.....	Chalk and Calcareous Shale.....	225	
Benton Group— Carlile formation..	Gray Shales with thin sandstones, limestone and concretionary layers.....	500-750	do
Greenhorn Lime- stone.....	Impure, slabby lime- stone.....	50	do
Graneros Shale.....	Dark shale with lenses of massive sandstone in its lower part at some places.....	900	do
Dakota Sandstone..	Massive buff sandstone	32-150	do
Fuson.....	Very fine grained sand- stone and massive shale. White to pur- ple color.....	30-100	do
Minnewasta Lime- stone.....	Gray limestone.....	0-30	do
Lakota.....	Massive buff sandstone with some shale.....	200-350	do
Morrison Shale....	Pale, grayish green shale.....	0-150	Jurassic
Unkpapa Sandstone	Massive sandstone white, purple, red buff.....	0-250	do
Sundance.....	Thin limestones. Dark drab shales and buff sandstones. Massive sandstone at base.....	60-400	do
Speartish.....	Red, sandy shale with gypsum beds.....	350-500	Triassic
Minnekahta Lime- stone.....	Thin-bedded, gray or purple limestone.....	30-50	Permian
Opeche.....	Red, slabby limestone and sandy shale.....	100-130	Permian
Minnelusa.....	Sandstones, mainly buff and red; in greater part calcareous. Some shales and thin lime- stones included.....	400-150	Carboniferous
Pahasapa Lime- stone.....	Massive gray limestone	250-500	do
Englewood Lime- stone.....	Pink, slabby limestone	25	do
Whitewood Lime- stone.....	Buff colored, mottled limestone, with green- ish shales at top.....	0-80	Ordovician
Deadwood.....	Red-brown quartzite, calcareous shales and sandstones, locally conglomeratic, partly massive.....	1-150	Cambrian

areas are common. Such are the tongue-like extension between Hot Springs and Alabaugh canyon, the elongated irregular dome alongside the Chicago & Northwestern railway northwest of Rapid City, and the more or less circular outcrop about Green mountain, Strawberry mountain, Inyan Kara, Warren peaks, Elkhorn peak, Crook mountain Bear Butte etc.

The formation affords many fine springs, a feature of much interest. It is the source of the abundant thermal waters at Hot Springs and Cascade springs and of colder waters at many other places. Analyses as elsewhere given show this limestone to be of excellent character for various industrial uses. It serves for the manufacture of high grade lime and is indeed the chief source of such material for the Black Hills region. It was used for a considerable time in the smelter at Rapid City in the reduction of the siliceous gold ores of the northern Hills, the limestone being obtained alongside the Chicago & Northwestern railroad three miles northwest of Rapid City. It is now being extensively utilized in the cyanide plants of the Homestake Gold Mining Company in Lead, their two kilns of modern make being constantly in operation at the quarry on Elk creek near Doyle on the Burlington railroad a short distance above Piedmont. The following analyses of this limestone indicate its superior nature in the preparation of a high-grade Portland cement. Analysis No. 1 is by Professor M. F. Coolbaugh of the School of Mines, the material coming from an outcrop alongside the Missouri river and Northwestern railroad near the old Canyon Lake site, four miles west of Rapid City. Analysis No. 2 and No. 3 are from samples taken near Newcastle. These two analyses are given in Bulletin No. 315 of the U. S. Geological Survey.*

*Ball. Sydney H. Portland Cement Materials in Eastern Wyoming. Bulletin No. 315, U. S. Geol. Survey, p. 232-244.

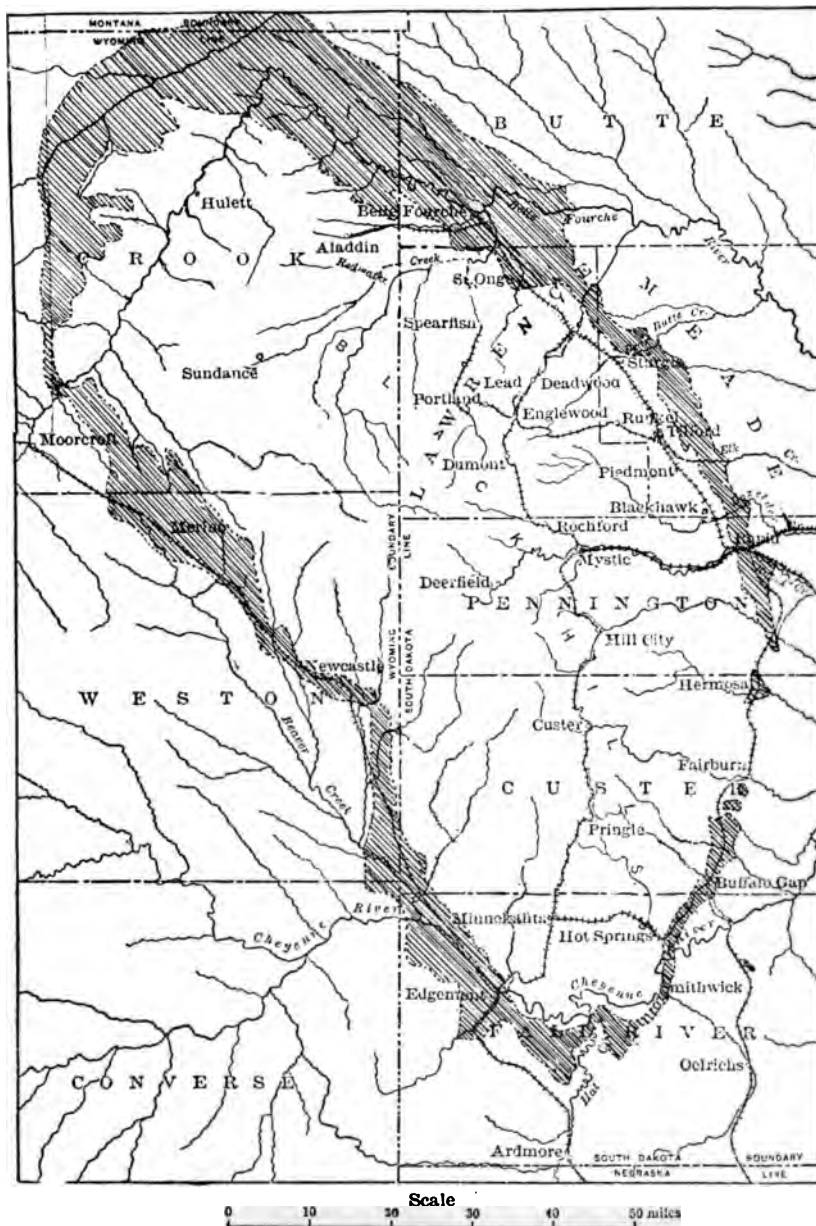
Table No. 2.**Analysis No. 1.**

Silica, SiO_2	1.21 Percent
Ferric Oxide, $\text{Fe}_2 \text{O}_3$	0.16
Alumina, $\text{Al}_2 \text{O}_3$	0.47
Titanium oxide, TiO_2	trace
Lime, CaO	54.56
Magnesia, MgO	0.41
Sulphur, S	0.11
Alkalies, $\text{K}_2 \text{O}$,	trace
$\text{Na}_2 \text{O}$,	trace
Phosphorus pentoxide, $\text{P}_2 \text{O}_5$	trace
Carbon dioxide, CO_2	42.90
Water, $\text{H}_2 \text{O}$	0.91
Total	100.13
Loss on ignition 42.95 percent.	

Table No. 2 A.**Analysis Nos. 2 and 3.**

	No. 1.	No. 2.
Silica, SiO_2	1.08 Percent	1.42 Percent
Alumina, $\text{Al}_2 \text{O}_3$	0.33	0.68
Ferric oxide, $\text{Fe}_2 \text{O}_3$	0.77	0.40
Manganese oxide, MnO ,	0.46	0.11
Lime, CaO ,	53.40	52.85
Magnesia, MgO ,	0.57	0.72
Sulphuric anhydride, SO_3 ,	0.12	0.12
Alkalies, $\text{Na}_2 \text{O}$,	0.36	0.76
$\text{K}_2 \text{O}$,	0.16	0.30
Water at 100°C	0.20	0.10
Ignition loss	42.92	42.78
Total	100.37	100.24

The Graneros Shale. The Graneros shale is the lowest member of what is frequently known as the Benton group. Lying as it does just outside the main Cretaceous hogback its outcrop completely encircles the Black Hills uplift as a broad belt of low undulating hills and valleys and serves as the innermost fringe of the great plains of the Black Hills region.



Map showing outcrop of the Graneros formation



The formation is made up distinctively of fine-grained dark gray to black shale, but there is considerable modification of this simple character in many places, especially in that portion of the area lying within the borders of Wyoming. Here a well-defined four-fold character generally shows itself, viz., first, a lower portion of fine black fissile shale 150 to 300 ft. thick; above this, massive grayish-buff sandstone of varying thickness up to 40 ft.; following this a series 250 to 300 ft. thick of dark shales of hard texture which weather to a distinct grayish white color; lastly, at the top a series of very black shales 400 to 500 feet thick, much resembling the shales of the lowest member. In that portion of the Black Hills region lying within South Dakota the four fold character is less prominent and particularly is this true so far as concerns the eastern and southern portions of the uplift.

The sandstone member varies greatly in thickness and hardness; sometimes it stands out in bold cliffs much like the Dakota sandstone whose texture and grayish-buff color it closely simulates. Elsewhere it is much concealed and over considerable areas it is thin or absent. Near Newcastle where this member reaches local prominence the rock contains petroleum as indicated by certain bore holes and by small flows from several natural springs. The sandstone shows in various places along the eastern side of the Black Hills, as, for example, at Rapid City and Hermosa, but here it partakes more of the nature of greatly elongated lenses and, except for a few lenticular hills, is of little or no topographic significance.

The hard grayish shale member, now commonly designated as the Mowrie beds, from Mowrie creek near Buffalo, Wyoming, where it was first studied, is prominent in much the same areas as the underlying sandstone except that it partakes less of the lenticular nature of the latter. Its greatest thickness is apparently in the vicinity of Belle Fourche and northwest of there along the Belle Fourche and the Little Missouri



ridges. Ridges often result from the more rapid wearing away of the softer shales and these ridges by contrast of color, by topographic importance and by their general wooded covering serve admirably in delineating the outcrops of these beds from the generally non-wooded darker shales of the lower and the upper members. The beds are further characterized by the presence of multitudes of fish scales in almost all good exposures. Southeast of Belle Fourche the gray color and the indurated nature become gradually less distinctive and the fish scales grow fewer in number until at Rapid City only the closest scrutiny establishes the presence of any portion of the member.

The lowest member needs little more character description than already given. With the exception of the passage beds of alternating shales and sandstones near the bottom and occasional bands of fair to good sized lime-clay concretions it is practically entirely a fine fissile, black shale. It lends itself to especial attention here in that the shale material used with limestone from the Minnekahta formation in the preparation of the Portland cement described elsewhere in this bulletin was obtained from this member. The following chemical analyses shows its favorable character. No. 1 is by Professor Coolbaugh of the School of Mines and represents material obtained a few hundred yards north of the Hinrichs-Lanphere saw mill in Rapid City. No. 2 represents material from near Newcastle and is recorded in Bulletin No. 315 of the U. S. Geological Survey.*

*Ball. Sydney H. Portland Cement Materials in Eastern Wyoming. Bulletin No. 315, U. S. Geol. Survey, p. 232-244.

Table No. 3.

Analysis No. 1 ,	
Silica, SiO_2 ,	58.74 Percent
Ferric oxide, $\text{Fe}_2 \text{O}_3$	3.87
Alumina, $\text{Al}_2 \text{O}_3$,	18.97
Titanium oxide, TiO_2 ,	0.71
Lime, CaO ,	0.93
Magnesia, MgO ,	1.62
Sulphur, S,	0.21
Alkalies, $\text{K}_2 \text{O}$,	1.49
$\text{Na}_2 \text{O}$,	0.58
Phosphorus pentoxide, $\text{P}_2 \text{O}_5$	1.44
Manganese oxide, MnO ,	trace
Loss on ignition	11.93
Total	100.24

Table No. 4.

Analysis No. 2.	
Silica, SiO_2	58.82 Percent
Alumina, $\text{Al}_2 \text{O}_3$,	16.43
Ferric oxide, $\text{Fe}_2 \text{O}_3$	4.47
Manganese oxide. MnO .	0.24
Lime, CaO ,	0.54
Magnesia, MgO ,	1.68
Sulphuric anhydride, SO_3	1.32
Alkalies, $\text{Na}_2 \text{O}$,	0.33
$\text{K}_2 \text{O}$,	2.18
Water at 100°C ,	6.39
Ignition loss,	7.93
Total	100.33

There is little or no reason for believing that much of the shales of the higher members of the formation would not lend themselves as freely to the production of good cement as the lowest member, although little experimental work has been carried on by way of demonstrating their real value for such purpose.

The upper black shale member much resembles the lowest member. It is generally thicker and is inclined to be more abundantly supplied with lime-clay

concretions. These concretions sometimes reach a diameter of five or six feet or more. Thin bands of limestone are occasionally found. Some of these are highly fossiliferous and, while never of great thickness, they occasionally are able to control the topography sufficiently to outline ridges and hills of some prominence.

The formation taken as a whole is well exposed. The outcrop is generally wide. This is more particularly true around the northern end and along the western side of the Hills where for many miles it serves as a wide valley bed for the Belle Fourche and the Little Missouri rivers and their tributaries, the width of outcrop in places reaching ten or a dozen miles or more. Along the eastern foothills the outcrop is narrower. From Whitewood creek southward to Spring creek it varies from one to four or five miles. South of Spring creek it is much concealed by unconformable Tertiary deposits. Throughout the entire region alluvial deposits cover up considerable areas along the streams and higher gravels veneer many of the gentle slopes and flat topped hills and ridges. The alluvial deposit is particularly prominent along the Belle Fourche river and the Little Missouri river in the northern and northwestern part of the area and along lower Beaver creek and certain portions of the Cheyenne river in the southern part. This covering prevails to a less extent elsewhere but is of significance wherever the formation is crossed by streams of a meandering nature.

The Graneros, like the Minnekahta, is favorably situated with reference to railroads. Northwest of Newcastle and between Newcastle and Edgemont the Burlington is built upon this formation, for many miles. This road could easily reach it by short extension near Piedmont or near Spearfish if such should be desired. At Rapid City the formation is convenient to the Missouri river and Northwestern, to the Chicago, Milwaukee and St. Paul, and to the two lines of

the Chicago & Northwestern. South of Rapid City to Buffalo Gap the Chicago & Northwestern touches it at many points. North of Rapid City to Whitewood this road lies within the red valley but even here easy access is permitted to the Graneros by the many notches through the intervening hogback ridges. North of Whitewood the Belle Fourche branch of the Chicago & Northwestern railroad quickly passes outside the red valley to the formation. It then follows the general direction of outcrop to and beyond Belle Fourche, being flanked on both sides by exposures in most convenient manner. In much the same way west of Belle Fourche the formation lies convenient to the Wyoming and Missouri River railroad.

The Niobrara Formation. The Niobrara formation lies just beneath the Pierre shale. Compared to the Pierre it is thin, being seldom more than 225 ft. thick and around the northern end of the uplift it is approximately 100 ft.

The material is very soft, is highly calcareous, and partakes more or less of the nature of an easily pulverized chalky limestone. Fresh material is of a bluish-gray color but outcrops are generally well weathered and disintegrated and in this condition the material is of a rich creamy yellow color.

The formation seldom develops any topographic features of significance but its pronounced yellow color renders the formation conspicuous whenever the outcropping surface is broken. The fossil oyster, *Ostrea congesta*, occurs in abundance in occasional thin indurated bands and this also serves as a distinctive feature.

Near the head of the Little Missouri river west of the Bear Lodge range and in the vicinity of Newcastle where local disturbances have given the formation a steep dip the width is only a few yards but frequently elsewhere it reaches one mile or more.

In view of the fact that the formation outcrops continuously and in a fairly regular manner around

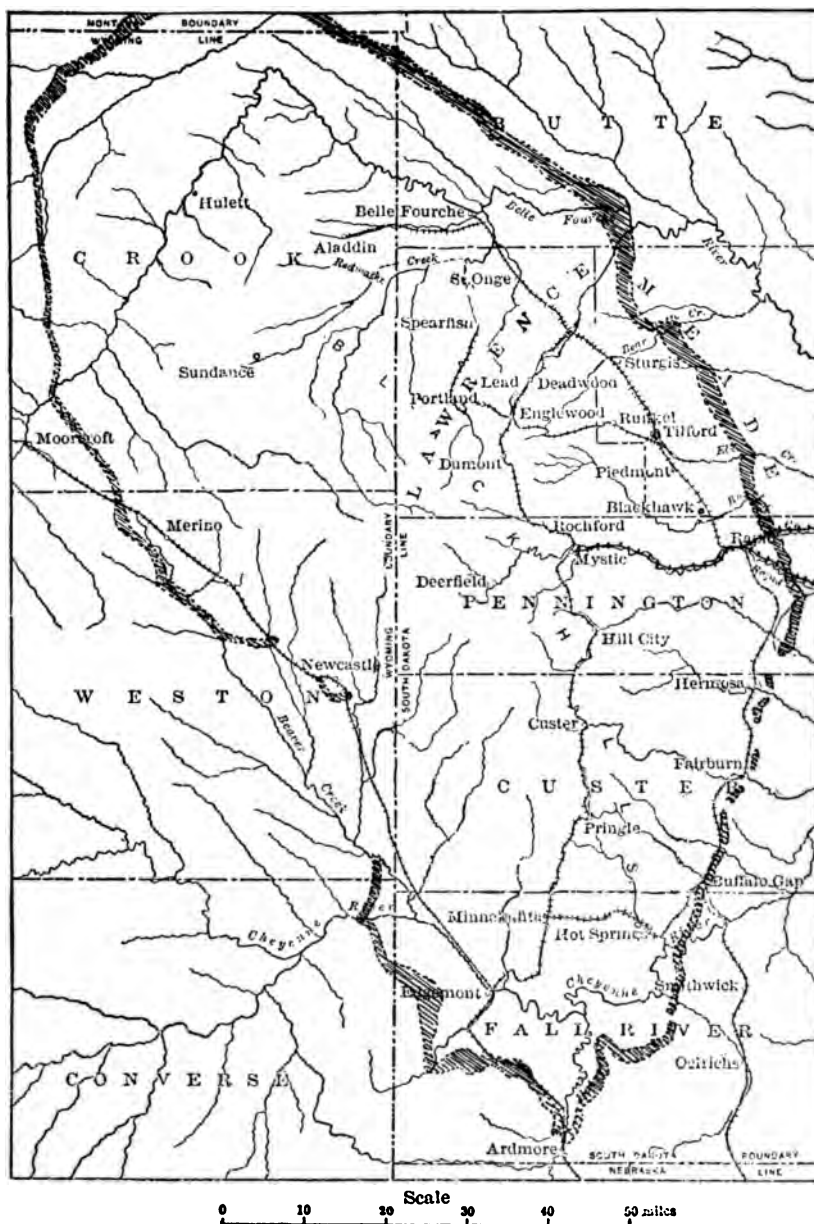
the Black Hills and is so readily distinguished in the field it serves nicely as a stratigraphic guide and delineates in an excellent manner the plainward extent of the more pronounced structural features of the Black Hills uplift.

The Niobrara is the formation that affords much of the raw material for the Portland cement plant at Yankton in the southeastern part of the state. The interesting feature with reference to the Black Hills area is that the chemical nature of the rock as revealed by analysis, while not uniform, indicates that this formation can furnish in places within the Black Hills area a most excellent material for natural cement. Its physical condition is almost everywhere particularly favorable. The shaly pulverent nature of the material would allow for easy excavation and doubtless steam shovel operation could be carried on to considerable depth. The chemical nature varies and is not always satisfactory but the following analysis by Professor Coolbaugh of the School of Mines from material near Antelope creek ten miles east of Tilford shows a particularly favorable composition and indicates the possibility of utilizing this material to most excellent advantage:

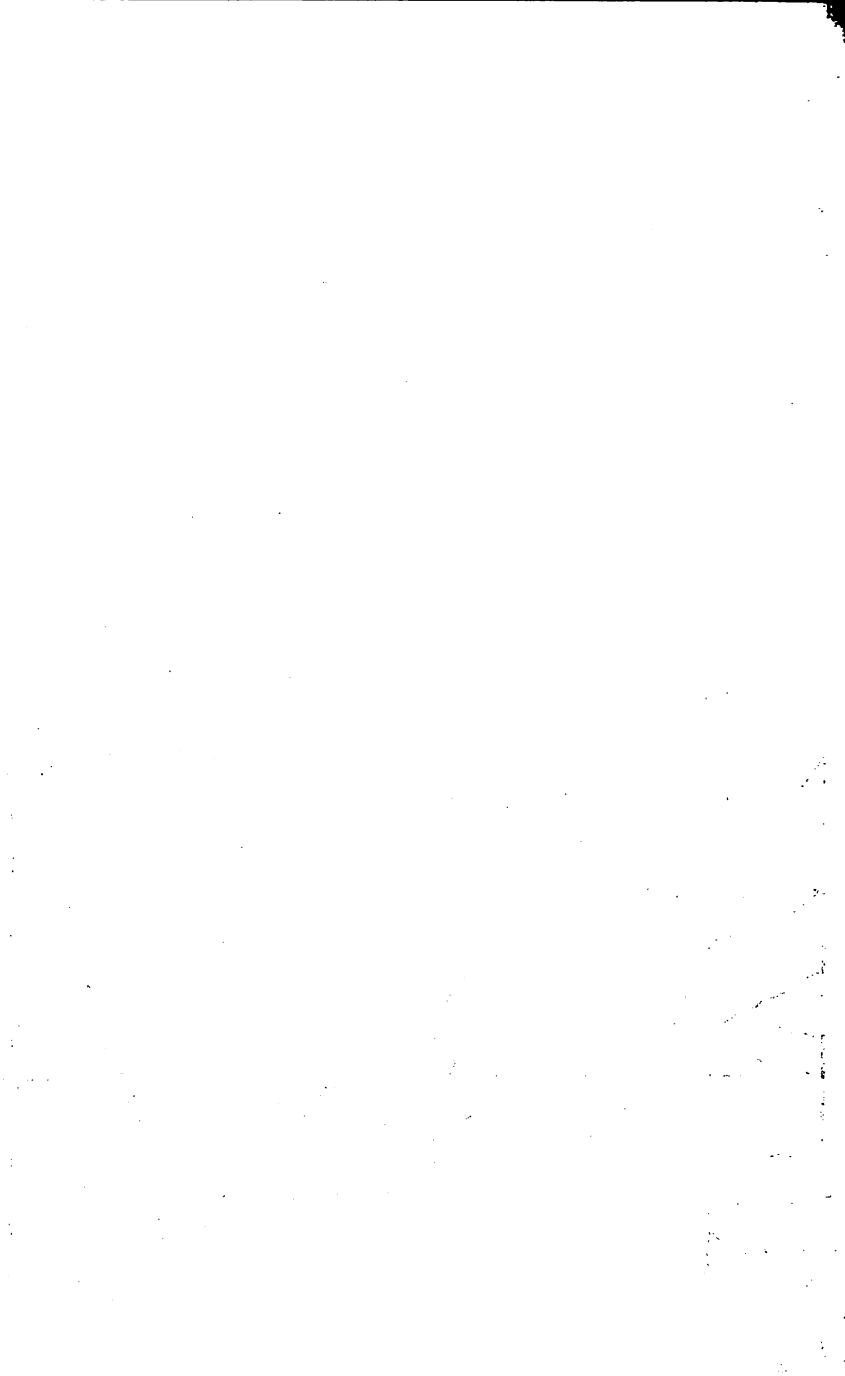
Table No. 5.

Silica, SiO_2 .	15.51 Percent
Ferric oxide, $\text{Fe}_2 \text{O}_3$ and Alumina, $\text{Al}_2 \text{O}_3$	5.80
Lime, CaO .	38.85
Sulphur, S	trace
Magnesia, MgO .	1.08
Alkalies, $\text{K}_2 \text{O}$, and $\text{Na}_2 \text{O}$.	1.50
Loss on ignition	36.67
Total	99.41

This may be more readily compared with the analysis of Portland cement manufactured from the Minnekahta-Graneros mixture given elsewhere in this bul-



Map showing outcrop of the Biobrarra formation



letin by recalculating so as to omit reference to loss on ignition. The analysis thus arranged is as follows:

Table No. 6.

Silica, SiO_2 ,	24.65 Percent
Ferric oxide, $\text{Fe}_2 \text{O}_3$ and Alumina, $\text{Al}_2 \text{O}_3$	9.16
Lime, CaO ,	61.36
Sulphur, S, (estimated)	0.20
Magnesia, MgO ,	1.72
Alkalies, $\text{K}_2 \text{O}$ and $\text{Na}_2 \text{O}$,	2.52
Total	99.61

Table No. 7.

	No. 4. Near Rapid City.	No. 5. Bear Butte Pierre
Silica SiO_2 ,	22.47	6.81
Ferric Oxide and Alumina	9.80	3.23
Lime CaO ,	25.01	46.75
Magnesia, MgO :	1.54	0.93
Alkalies,	0.75	1.43
Sulphur,	1.84	trace
Loss on ignition	38.25	39.56
Total	99.66	99.71

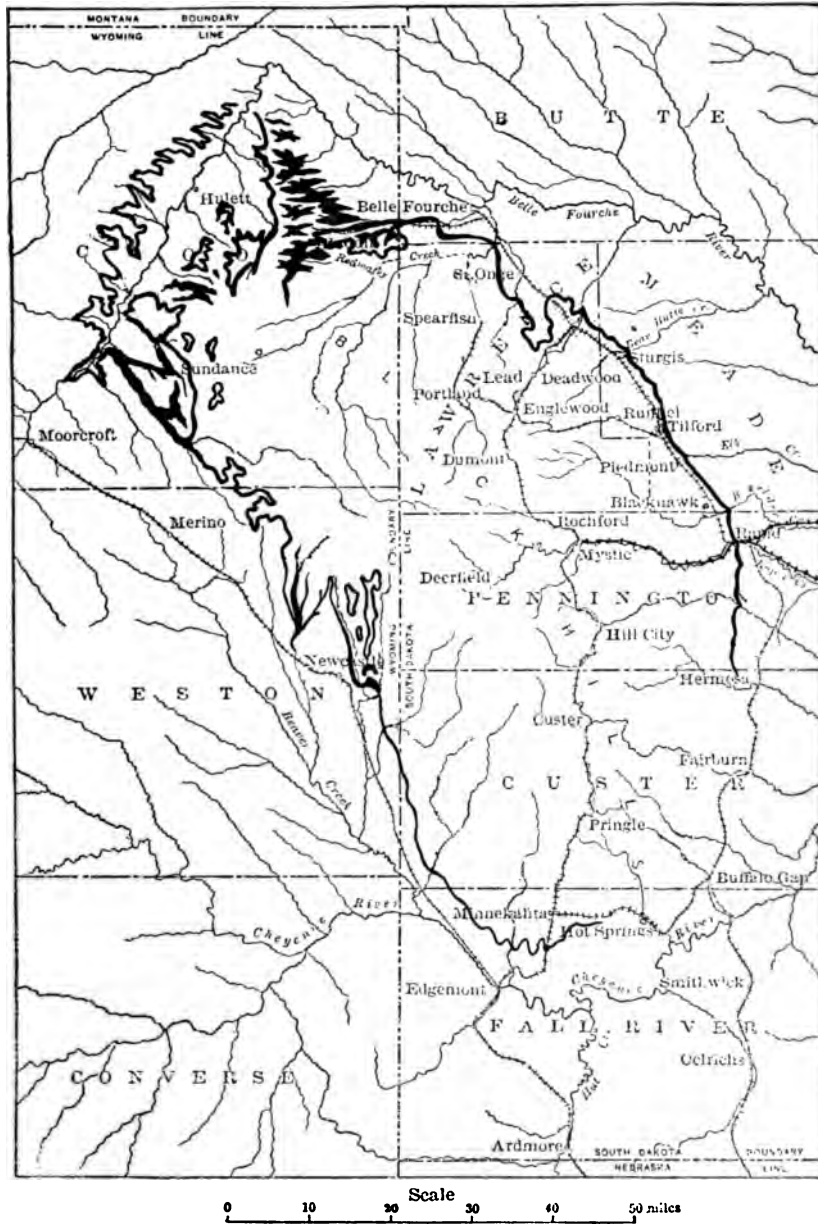
The Burlington and Missouri River railroad follows the outcrop of the formation for some miles near Ardmore and near Newcastle and crosses it again near Moorcroft. The Chicago & Northwestern railroad crosses it near Buffalo Gap, then follows it fairly closely to Rapid City. Just east of Rapid City the Pierre, Rapid City & Northwestern cuts across the formation in a particularly favorable manner while the Chicago, Milwaukee & St. Paul could reach similarly good outcrops near by with little side trackage. Between Rapid City and Whitewood the formation outcrops in a wide belt several miles east of the railroad but this could be easily reached if desired through the various gaps in the hogback ridges.

The Morrison Formation. The Morrison formation of early Cretaceous or late Jurassic age lies just beneath the Lakota sandstone. It does not completely encircle the Hills, there being a considerable space in the southeastern portion of the uplift where it is absent. Along the eastern side of the Hills it is underlain by the massive soft Unkapapa sandstone but along much of the western portion of the uplift the Unkapapa is absent and it is underlain by the Sundance formation.

The formation is made up of shales and thin nodular bands of white argillaceous limestone, the shales greatly predominating. Sometimes the clay-lime nodules are of little or no significance and occasionally thin shaly sandstones appear, the latter showing best in the Bear Lodge mountains. The shales carry more or less carbonaceous matter and vary much in color. Olivine green predominates in fresh exposures but pale greenish gray, yellowish gray, pink, red, maroon, chocolate, purple, and black are not infrequently observed. A characteristic and fairly common feature of the formation is the presence of large saurian bones near the bottom of the formation. Several localities have afforded good specimens.

The formation where best exposed varies in thickness up to 160 feet or more. In the Bear Lodge mountains and southward it varies from 40 ft. to 160 ft. Along the northeastern side of the Hills the thickness varies in much the same way. On the Oelrichs quadrangle it is absent.

Exposures are good in many places and convenient to the railroads. The Chicago & Northwestern parallels the outcrop all the way from Rapid City to Whitewood and could easily tap many of the exposures by short spur trackage, the outcrops being all to the east of the track and at various convenient heights above the main line. The Burlington and Missouri River railroad crosses the formation between Edge-



Map showing outcrop of the Morrison formation



mont and Minnekahta and is fairly convenient to it near Newcastle and Piedmont. The Wyoming and Missouri River railroad follows the formation for some distance near Aladdin.

Little experimental study has been given this formation but it is worthy of consideration. An analysis* of material obtained near Newcastle gives the following favorable composition:

Table No. 8.

Silica, Si O ₂ ,	45.78 Percent
Alumina, Al ₂ O ₃	12.92
Ferric oxide, Fe ₂ O ₃	3.95
Manganese oxide, MnO,	0.53
Lime, CaO,	0.56
Magnesia, MgO,	0.73
Sulphuric anhydride, SO ₃	0.48
Alkalies, Na ₂ O,	0.64
K ₂ O,	0.50
Water at 100° C,	8.26
Ignition loss, largely carbonaceous matter	26.32
Total	100.42

The Carlile Formation. The Carlile formation outcrops immediately within the Niobrara and constitutes the upper portion of the Benton group. It is made up of a series of thin black shales with occasional thin impure sandstone and limestone bands. In places the limestone is quite argillaceous and takes on the form of large concretionary or lenticular masses. These sometimes contain fossils.

In the Devils Tower quadrangle the formation is made up of three fairly distinct divisions, viz., an upper division, chiefly shale, 300 feet thick; a middle division 125 feet thick, concretions and shale; and a lower division 200 feet thick, mostly shale. Elsewhere this threefold nature is absent or is not sufficiently prominent to disclose itself in any characteristic man-

*Ball. Sydney H. Portland Cement Materials in Eastern Wyoming. Bulletin No. 315, U. S. Geol. Survey, p. 236.

ner. The total thickness varies from about 400 feet near Buffalo Gap to about 700 feet in the vicinity of Newcastle. The shale portions much resembles the shales of the Pierre and the Graneros and doubtless the chemical composition is much the same.

The formation is readily accessible to the various railroads in much the same manner as the overlying Niobrara. Since it has not been carefully studied as to possibilities in the way of affording ingredients for cement manufacture further description need not be given at this time.

The Pierre Formation. The Pierre formation is the latest Cretaceous formation that outcrops within the immediate Black Hills region. It completely encircles the uplift as a broad belt and is one of the greatest formations of the Plains region. West of the Hills its outcrop averages perhaps five or six miles in width. Northeast, southeast, and south of the Hills it reaches several times this width while to the east of the Hills it extends far beyond the limits of the regions under discussion. Every railroad entering the Hills traverses the formation for several or many miles and good exposures are abundant and convenient.

The thickness of the formation is given as approximately 1200 feet. The material is almost wholly black shale. Weathered surfaces show lighter color and in the lower portion where some lime enters into the composition the color is inclined to a dull yellowish color. Lime and lime-iron concretions are abundant at several horizons. These are often highly fossiliferous, particularly those in the upper part of the formation and the invertebrate forms that they contain are varied in character and often beautifully preserved. The formation is abundantly exposed and readily distinguished. For further details of structure, distribution and physical character of this formation as well as for the Carlile the reader is referred to the various publications listed on a subsequent page.

Little attention has been given to the accurate chemical nature of the shales. One analysis* made from material obtained one mile above Spencer siding on the Burlington and Missouri River railroad south-ly known as the "red beds." This formation complete-southeast of Newcastle, is as follows:

Table No. 9.

Silica, SiO_2 ,	60.66 Percent
Alumina, $\text{Al}_2 \text{O}_3$	22.13
Ferric oxide, $\text{Fe}_2 \text{O}_3$	1.21
Manganese oxide, MnO ,	0.44
Lime, CaO ,	1.59
Magnesia, MgO ,	1.54
Sulphuric anhydride, SO_3	0.43
Alkalies, $\text{Na}_2 \text{O}$,	0.53
$\text{K}_2 \text{O}$,	3.16
Ignition loss	9.28
Total	99.97

The above analysis shows certain undesirable percentage of ingredients but field observation furnish good reason for believing that a series of analyses of material selected from various localities would show a fair number with favorable proportions of the various important elements.

Gypsum. A brief word concerning the nature and occurrence of Black Hills gypsum may be of interest here in view of the fact that gypsum enters in a minor way into the manufacture of cement.

The deposits of Black Hills gypsum occur at various horizons within the Spearfish formation, popularly known as the "red beds." This formation completely encircles the Hills and good exposures seldom fail to show gypsum, nearly pure white, in sufficient quantity and of sufficient purity to be of commercial value. The deposits are extensive and convenient. They are sometimes lenticular but more often they occur in beds

*Ball. S. H. Portland Cement Mat. in Eastern Wyoming. Bul. 315, U. S. G. S. p. 238.

of nearly uniform thickness and in some places where the outcrop is favorable these white beds may be traced across the landscape for many miles as they stand out in prominent contrast to the enclosing red sandy shales.

The gypsum is of a high degree of purity and for several years has been utilized in the manufacture of stucco or plaster. Two plants are now in active operation, one at Hot Springs and one near Rapid City. The Hot Springs plant has been in interrupted operation for several years. The Rapid City plant was placed in commission early in the year 1908. Both plants are convenient to large bodies of good raw material.

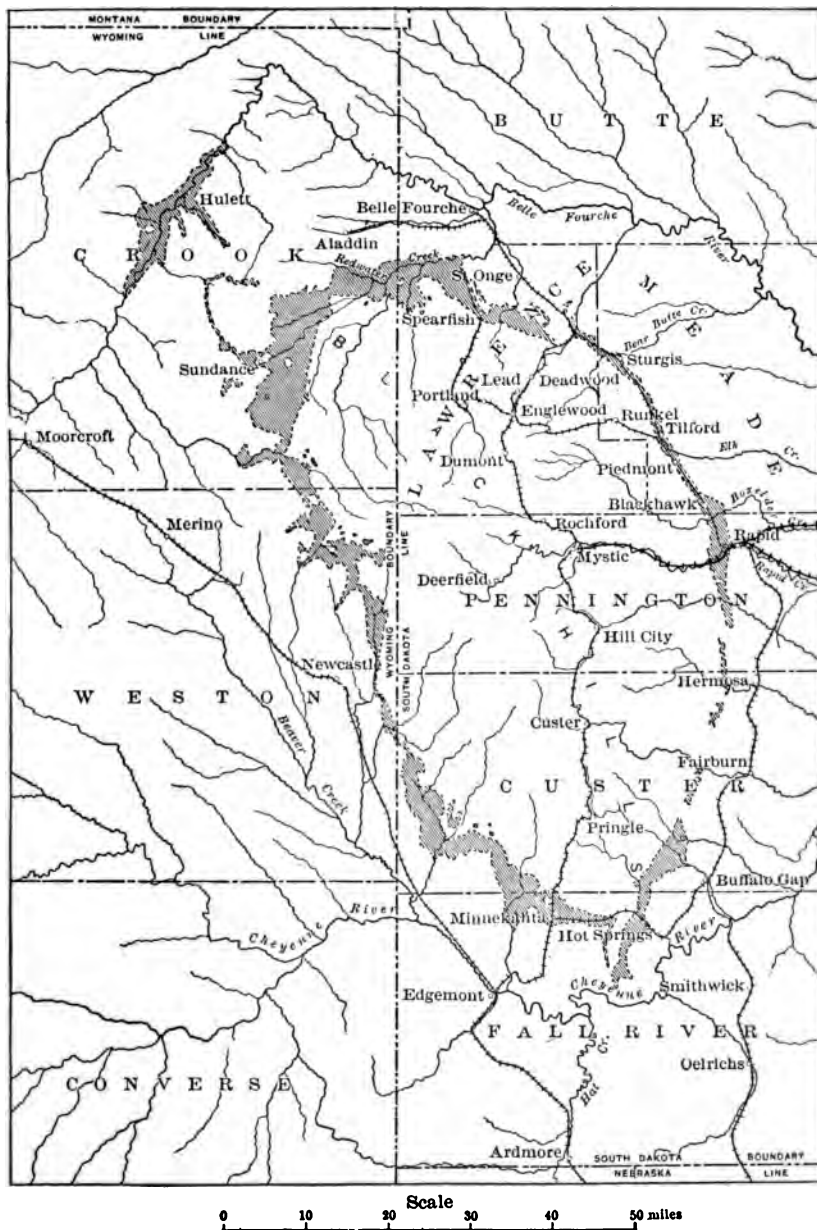
Analysis of the Hot Springs gypsum made by Professor Coolbaugh show the following composition. No. 1 is from a thirteen foot bed near the bottom of the exposure and No. 2 is from a four foot, the two being separated by one foot of red shale carrying only thin seams of gypsum. Both beds are utilized.

Table No. 10.

Silica, SiO_2 ,	0.12	0.09 Percent
Ferrie oxide, $\text{Fe}_2 \text{O}_3$		
Alumina, $\text{Al}_2 \text{O}_3$	0.12	0.06
Sulphuric anhydride, SO_3	47.77	44.86
Lime, CaO ,	33.00	32.89
Magnesia, MgO ,	0.10	0.28
Loss on ignition	20.85	21.41
Total	101.97	98.59

Mr. Steiger of the U. S. Geological Survey laboratory gives the following analysis of material from near Cascade Springs:*

*Darton, N. H. Gypsum Deposits in South Dakota. Bulletin No. 223, U. S. Geological Survey, p. 76-78.



Map showing outcrop of the gypsum-bearing Spearfish formation
 Reproduced from U. S. G. S. Bulletin No. 223. New railroads inserted



Table No. 11.

Lime, CaO,	32.44 Percent
Magnesia, MgO,	0.33
Alumina, Al ₂ O ₃	0.12
Silica, Si O ₂	0.10
Sulphuric anhydride, SO ₃	45.45
Carbon dioxide, CO ₂ ,	.85
Water, H ₂ O,	20.80
Total	100.09

Additional Literature. The reader who may wish to examine more fully into the details of distribution and description of the various geological formations described or mentioned in this paper will find much additional information in the following atlas folio publications of the U. S. Geological Survey:

Darton, N. H., Oelrichs folio. No. 85, 1902.

Darton, N. H. Newcastle folio. No. 107, 1904.

Darton, N. H., and Smith, U. S. T. Edgemant folio No. 108, 1904.

Darton, N. H., Sundance folio, No. 127, 1905.

Darton, N. H. and O'Harra, C. C. Aladdin folio, No. 128, 1905.

Darton, N. H., and O'Harra, C. C., Devils Tower folio No. 150, 1907.

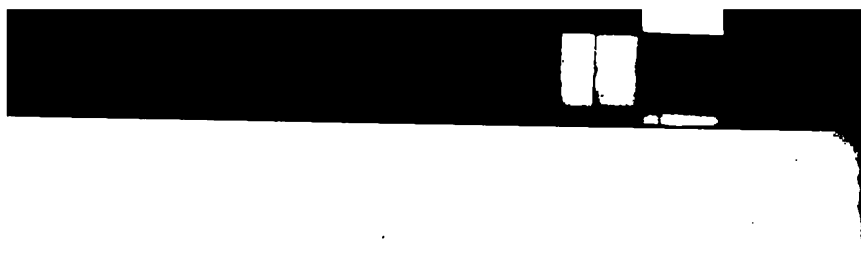




PART II.

OUTLINE FOR THE ANALYSIS OF CEMENTS AND CEMENT MATERIALS.

M. F. COOLBAUGH, M. A.





Outline for Analysis of Cement and Cement Materials.

M. F. COOLBAUGH, M. A.

The outline scheme for the analysis of cements will serve in many places as a scheme for the analysis of limestones, raw mixtures, shales and clays.

Decomposition.—With highly silicious material decomposition can be effected by treatment with hydrochloric and nitric acids, filtration, fusion of the residue with sodium carbonate, and solution of the fused mass in water and hydrochloric acid. Or the fusion may be made directly without a previous treatment with acids. For the decomposition of limestones or unburned mixtures, ignite material with one-half to an equal weight of sodium carbonate and treat mass with diluted hydrochloric acid.

Silica.—Two evaporations are essential for this determination when considerable accuracy is required. Even then a complete separation is not effected, as some silica will be found with the iron and alumina precipitate. Some alumina will also be found with the dehydrated silica. Corrections for these small amounts of impurities are not, however, necessary in technical work, since the weights tend to counterbalance each other. For greater accuracy, the silica should be driven off by treatment with hydrofluoric acid and a few drops of sulphuric acid. The residue should be

added to the precipitates from the ammonia treatment.

Iron and Alumina.—The precipitates of iron and aluminum hydroxides, which contain also titanic-acid, ferric phosphate, and a small amount of silica, is purified from calcium and traces of manganese by solution in nitric acid and reprecipitation with ammonia. The calcium in the first precipitate is caused by impurities of ammonium carbonate in the ammonia, or by carbon dioxide in the air of the laboratory. The manganese is not separated even by two precipitations unless the content of that element is small. If this is not the case, separate it from the iron and aluminum by precipitation of the latter as basic acetates in a dilute acetic acid solution containing sodium acetate. The amount of silica is separated after the fusion with the acid sodium sulphate, as in (3), and evaporation of the sulphuric acid solution to low bulk. The weight found here should be added to that already found.

Titanium Oxide.—The titanium is determined in the solution from the titration of iron in (3). Add ten c.c. hydrogen peroxide, make to a definite bulk, and compare color with that of a standard solution of titanium treated in a similar manner.

Manganese.—This is determined in the filtrate from the iron and alumina precipitation. It is precipitated with ammonium sulphide, dissolved in nitric acid and determined colorimetrically by use of silver nitrate and ammonium persulphate.

Lime.—Acidify with hydrochloric acid the combined filtrates from the aluminum and ferric hydroxides precipitates, or the filtrate from the manganese determination, heat to boiling, add 10 to 12 c. c. of a saturated solution of ammonium oxalate and slowly neutralize with ammonia. The longer the time taken for neutralization the less danger there is of contamination by magnesium. When greater accuracy is desired, the calcium oxalate is filtered, ignited, dissolved

Scheme for Analysis of Cement.

PART I.

Take 1gr. of the finely ground material and treat with dilute HCl and filter. Dry the residue, fuse with Na₂CO₃ take up in water and HCl and add to the main solution. Evaporate to dryness, dehydrate at 120°C, take up in water and HCl and filter. Repeat evaporation and dehydration.

(1) Residue Dry, ignite and weigh as SiO₂

(2) Solution. Make alkaline with NH₄OH, boil and filter. Dissolve precipitate in dilute HNO₃ and reprecipitate with NH₄OH and filter; combine filtrates.

(3) Precipitate Fe (OH) ₃ , Al (OH) ₃ . Dry, ignite and weigh as Fe ₂ O ₃ and Al ₂ O ₃	(4) Solution. Make acid with HCl, heat to boiling, add (NH ₄) ₂ C ₂ O ₄ neutralize slowly with NH ₄ OH and filter.	(5) Precipitate Ca in dry, ignite and weigh as CaO.	(6) Solution. Acidify with HCl, concentrate to 15cc, add 50cc of a saturated solution of Na ₂ H ₂ P ₂ O ₄ boil and cool. Then add NH ₄ OH drop by drop until the precipitate begins to form, and finally add it in slight excess. Allow to stand several hours, filter, wash, ignite and weigh as Mg ₂ P ₂ O ₇
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PART II.

Heat 1gr. of the material with one half gr. of Na₂CO₃. Extract with water and filter. Reject residue unless P₂O₅ is to be determined. Acidify solution with HCl, add BaCl₂, boil, filter, dry, ignite and weigh as BaSO₄.

PART III.

Heat one half gr. of Cement with 4grs. of CaCO₃ and one half gr. of NH₄Cl. Extract with water and filter. Reject residue. To the solution add a few drops of BaCl₂ and an excess of (NH₄)₂CO₃. Filter and reject the precipitate. Evaporate the solution to dryness and drive off the NH₄OH salts. Take up in a small amount of water, add a few drops of (NH₄)₂C₂O₄ and filter into a weighed crucible. Evaporate to dryness, add a few drops of HCl, ignite gently and weigh the NaCl and KCl. Dissolve in a small amount of water add H₂PtCl₆, evaporate to low bulk add 85 per cent. alcohol and filter. Reject filtrate. Dissolve precipitate in a small amount of hot, water filter in a weighed crucible, evaporate to dryness dry at 105°C and weigh as K₂PtCl₆. Calculate K₂PtCl₆ to KCl and subtract from the combined weights of the Chlorides to obtain the NaCl.

in hydrochloric acid, made alkaline with ammonia, boiled and the small amount of aluminum hydroxide filtered out and added to that already found. The calcium is reprecipitated as the oxalate, filtered, ignited and weighed as calcium oxide, or filtered, washed, dissolved in sulphuric acid and the oxalic acid titrated with potassium permanganate.

Magnesia.—For an accurate determination of this substance, the first precipitate should be dissolved in hydrochloric acid, two c. c. of a saturated solution of sodium ammonium phosphate added, and then ammonia, drop by drop, as described in (6) in the scheme. The reason for the second precipitation is that the normal magnesium ammonium phosphate is not the only precipitate formed in the presence of a large excess of ammonium salts, but is contaminated by some $(\text{NH}_4)_4 \text{Mg} (\text{PO}_4)_2$ which yields $\text{Mg}_2 \cdot \text{P}_2 \text{O}_7$ only on very strong ignition.

Sulphur.—Ignite the material with one-half its weight of sodium carbonate and a small amount of sodium nitrate, extract with water, filter, acidify filtrate with hydrochloric acid, and precipitate the sulphur, with barium chloride as barium sulphate. The sodium nitrate is added to oxidize the sulphur from the the sulphide to the sulphate condition.

Phosphoric Anhydride.—For this determination treat the residue obtained in the sulphur determination with nitric acid, evaporate to dryness to remove silica, take up in dilute nitric acid, filter, treat residue with hydrofluoric and nitric acids, finally with nitric acid alone and unite solutions. Precipitate the phosphorus with ammonium molybdate, dissolve precipitate in dilute ammonia, acidify with sulphuric acid, reduce with zinc and titrate with potassium permanganate.

Carbon Dioxide.—Decompose the material with hydrochloric acid and absorb the carbon dioxide in soda lime or a solution of potassium hydroxide.

Alkalies.—For this determination follow the well

known method of Professor J. Lawrence Smith, the outline of which is given in the scheme.

Insoluble Residue.—Decompose material slowly with a 10 per cent solution of hydrochloric acid, filter, dry, ignite and weigh the residue.

Loss on Ignition.—Blast a weighed sample for fifteen minutes in a covered platinum crucible. Cool and weigh. Check the loss by blasting for another five minutes.

REFERENCES.

Report of the Sub-Committee on Uniformity in Analysis of Materials for the Portland Cement Industry. J. Soc. Chem. Ind. Vol. 21, p. 12-30.

Analysis of Materials for the Portland Cement Industry. By W. F. Hillebrand. J. Am. Chem. Soc. Vol. 25, p. 1180.

The Analysis of Portland Cement. By Bertram Blount. J. Am. Chem. Soc. Vol. 26, p. 995.

The Technical Analysis of Cements. By S. F. Peckham. J. Am. Chem. Soc. Vol. 26, p. 1636.

The analysis of Silicate and Carbonate Rocks. By W. F. Hillebrand. Bulletin 305, U. S. Geological Survey.





PART III.

THE PREPARATION OF THE CEMENT FROM
THE RAW MATERIAL, FOR EXPERI-
MENTAL PURPOSES.

C. H. FULTON, E. M.



The Preparation of the Cement.

C. H. FULTON, E. M.

The raw material, its extent and composition, for the manufacture of the cement has been described in Part I of this bulletin.

The limestone used in making the cement described below is from a cut on the Missouri River and Northwestern R. R. near Canyon Lake about four miles west of Rapid City and has the following analysis.

Silica	1.21
Ferric oxide	.16
Alumina	.47
Titanium oxide	trace
Lime	54.56
Magnesia	.41
Sulphur	.11
Alkalies	trace
Phosphorous pentoxide.....	trace
Carbon dioxide	42.30
Water above 100° C.....	.91
	100.13
Loss on ignition	42.95

The shales used is from the foot hills, one-half mile northwest from the center of Rapid City and has the following analysis:

Silica	58.47
Ferric oxide	3.89
Alumina	18.97
Titanium oxide	.71
Lime	.93
Magnesia	1.62
Sulphur	.21
Potassium oxide	1.49
Sodium oxide	.58
Phosphorous pentoxide	1.44
Manganese oxide	trace
Loss on ignition	11.93

100.24

This material was to be mixed in such proportion as to make a sound, strong Portland Cement. The composition of Portland Cement cannot vary within wide limits and certain ingredients like magnesia, and sulphuric anhydride must be low. The limit on magnesia is usually placed at 4 per cent in cement and that of sulphuric anhydride at 1.75 per cent. As regards the absence of both of these harmful ingredients the raw material is especially favored.

The necessary constituents of Portland Cement are silica, alumina and lime. According to Le-Chatelier, Portland cement clinker consists of alit, considered to be tri-calcium silicate $3\text{CaO}, \text{SiO}_2$ which is the active hardening element, and celit, considered to be tri-calcic aluminate,— $3\text{CaO}, \text{Al}_2\text{O}_3$ also setting and hardening in water. There are also present in small amounts calcium ferrate and mono, and dicalcium silicates.

Richardson states that the components of cement are present in the clinker as two solid solutions, alit—*a solution of tricalcic aluminate in tri-calcic silicate* and celit, *a solution of dicalcic aluminate in di-calcic*

silicate. The ratio of alit to celit may vary from 3 to 6 to 1.

According to Bleining* the limits of composition of Portland Cement are as follows:

Silica	19 to 26 per cent
Alumina	4 to 11
Ferric oxide	2 to 5
Lime	58 to 67
Magnesia	0 to 5
Sulphuric anhydride	0 to 2.5
Alkalies	0 to 3.0

The following are typical cements analyses.**

Lehigh Co., Penn.	Yankton, S. D.	Coldwater, Mich.
Silica	22.68	19.50 21.22
Alumina	6.70	7.70 7.51
Ferric oxide ...	2.35	4.30 3.83
Lime	62.30	60.00 63.75
Magnesia	3.41	0.80 0.82
Sulphuric		
anhydride ...	1.88	2.80 1.58
Alkalies		1.20
Loss on ignition.		 1.02

According to the constitution of the cement there must be a definite ratio between lime, silica and alumina which for American cements may be expressed by the following empirical formula:

$$\text{Lime} = \text{Silica} \times 2.7 + \text{alumina} \times 1.$$

Many cements come quite close to this composition though more generally the lime falls somewhat below the figure obtained by the calculation.

The dried raw materials, the compositions of which have been mentioned were mixed in the proportion of 1 part shale to 3.30 parts limestone, after considerable experimentation with somewhat different mixtures, this proportion yielding the best result. Ac-

*Manufacture of Portland Cements. Bul. No. 3, Ohio Geol. Survey.

**From Taylor's Practical Cement Testing.

According to calculation from analysis this mixture should burn to a cement of the following composition:

Silica	22.61 per cent
Alumina	7.43
Ferric oxide	1.60
Lime	65.51
Magnesia	1.07

The actual composition of the cement (sample No. 13) is as follows:

Silica	23.08 per cent
Alumina	7.12
Ferric oxide.....	2.07
Magnesia	1.08
Lime	64.80
Sulphuric anhydride.....	0.66
Potassium oxide	0.52
Sodium oxide	0.21
Titanium oxide	0.26
Phosphorous pentoxide.....	0.53
Manganous oxide	trace
Carbonic oxide	trace

Total100.33

In the burning curves shown in Fig. 11 this cement is represented by curves 9, 12 and 13. Curves 7 and 8 are those of a cement made of 1 part of shale, and 3.5 parts limestone and 0.04 parts iron ore containing 80 per cent of ferric oxide, this last being added to slightly increase the iron content of the cement. This cement has the following composition:

Silica	22.04 per cent
Alumina	8.05
Ferric oxide	2.67
Lime	65.53
Carbonic acid	.016

The Preparation of the Raw Material.—The limestone and shale were crushed in a small Gates breaker (laboratory size) to a one quarter inch ring, and dried at approximately 100° C. Each constituent was then

...also includes one of the silica contents of the

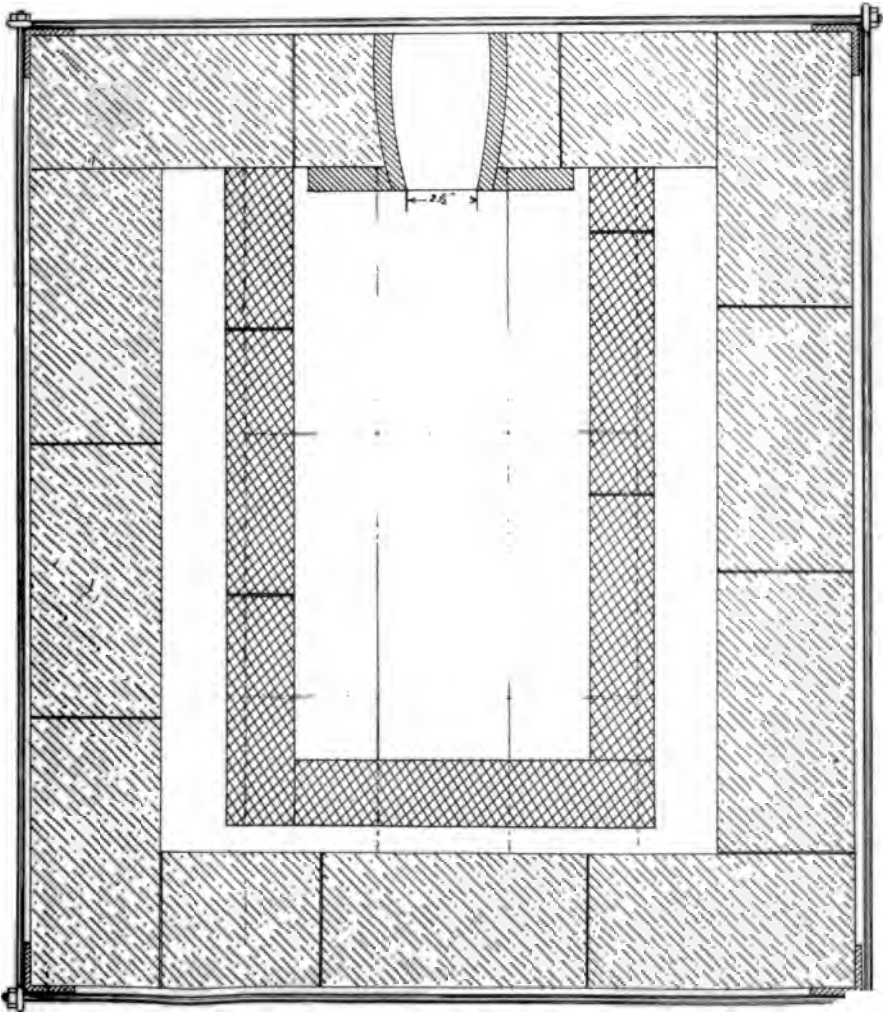
briquettes after burning make cement
The appearance of the clinker is an indi-
cator of the proper burning of the cement, and also

indicates roughly if the composition is approximately correct. Good clinker should be hard, but brittle, somewhat porous, but of sufficient specific gravity. The specific gravity of the burnt cement is the best general indication of proper burning. Depending somewhat upon composition the specific gravity of the ground cement should be from 3.10 to 3.20. These figures refer to cement that has been stored for some weeks. If the specific gravity is taken just after burning it will range from 3.15 to 3.25. Taking the figures for stored cement a gravity below 3.10 indicates unburning and one above 3.20, overburning. The clinker from cements high in lime are often rather light and porous, and that from cements high in alumina, dense and compact, relatively speaking. The last mentioned kind of clinker is very apt to "dust" when taken from the furnace, e. g., to fall apart into powder on cooling.

The Experimental Furnace.—The furnace for the burning of the cement mixture should be so constructed that a temperature of 1500°C . can be obtained with it. The generating of this temperature in *any considerable* space for a prolonged time is attended with some difficulties. The first attempts were made with a small gasoline fired assay crucible furnace lined with fire clay tiling and bound with sheet iron. With a 2 inch Carey burner and gasoline at 20 lbs. pressure a temperature of 1400°C was obtained in the focus of the burner flame, i. e. only within a small space. Only a few briquettes could be clinkered in this way while the others in the furnace would be much underburned. Another difficulty encountered was that where the cement briquettes were in contact with the furnace lining they absorbed silica and alumina, thus destroying the original composition of the mixture, and causing them to "dust" or slough away on cooling. The attempt to burn the briquettes in a pot furnace in direct contact with coke proved unsatisfactory for experimental purposes as the amount of ash absorbed by the



Legend
Fire brick
Magnesite
Chromite
Coal ash
Concrete
Plumbago



PLAN SECTION
Fig. 10.



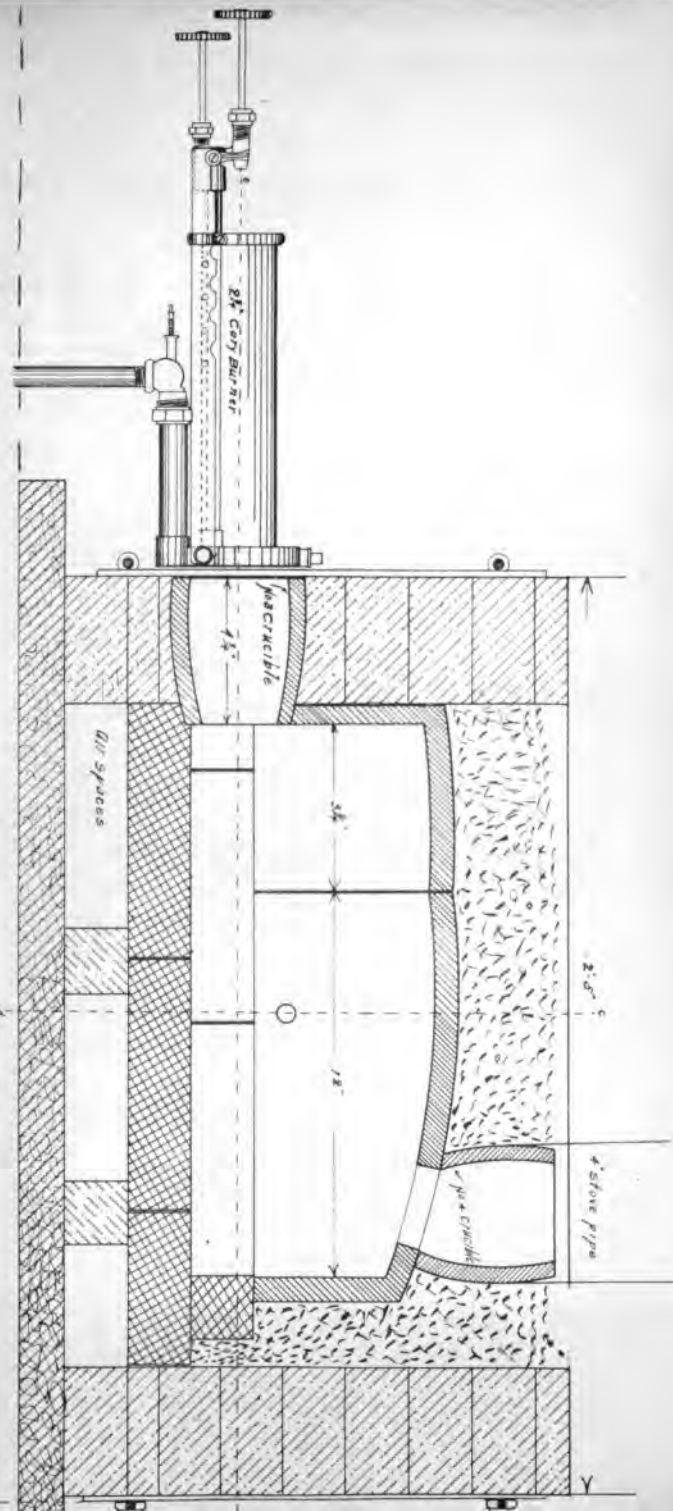
briquettes was such as to cause indefinite results. As a last resort the following furnace was constructed. A graphite crucible was cut lengthwise below the median line and the larger half used. A flue opening was made at the top near the closed end. Thoroughly burnt coal ashes were spread on a cement top table and were confined by a rectangle of fire brick. A layer of chromite brick (a neutral refractory substance) was placed on the ashes and formed the bottom of the furnace. On this was placed the improvised graphite muffle as shown in the accompanying drawings. The outside walls of the furnace were laid up of fire brick in a mortar of fire clay and cement. The space between the walls of the furnace and the muffle was filled with ashes as shown in the drawing.

The flue was connected by pipe to the chimney. The only opening into the furnace was through the "burner boss" which was made of a section of graphite crucible. Whenever the furnace was charged or discharged the burner boss was removed, giving an ample cylindrical opening into the muffle, flush with the chromite bottom. The firing was done with a 2 in. Carey burner, with gasoline as fuel.

The burner was so arranged as to swing readily away from the burner opening and leave free access to the furnace. A porcelain pyrometer tube reaching to nearly the center of the furnace was built into the one side wall and afforded the means of obtaining the thermo-couple readings of "burning." Gasoline was burnt under a pressure of 50 to 60 lbs. per sq. in. In order to burn the quantity of gasoline implied by this pressure in a 2 in. burner, the draft in the furnace had to be considerable. This was obtained by the flue connections mentioned above. A uniform temperature throughout the muffle, of nearly 1500° C could be readily obtained, and batches of cement of 2000 grams, completely and readily clinkered in from 1½ to 2½ hours. The cement briquettes never ad-

hered to the bottom of the furnace, and came out perfectly clean.

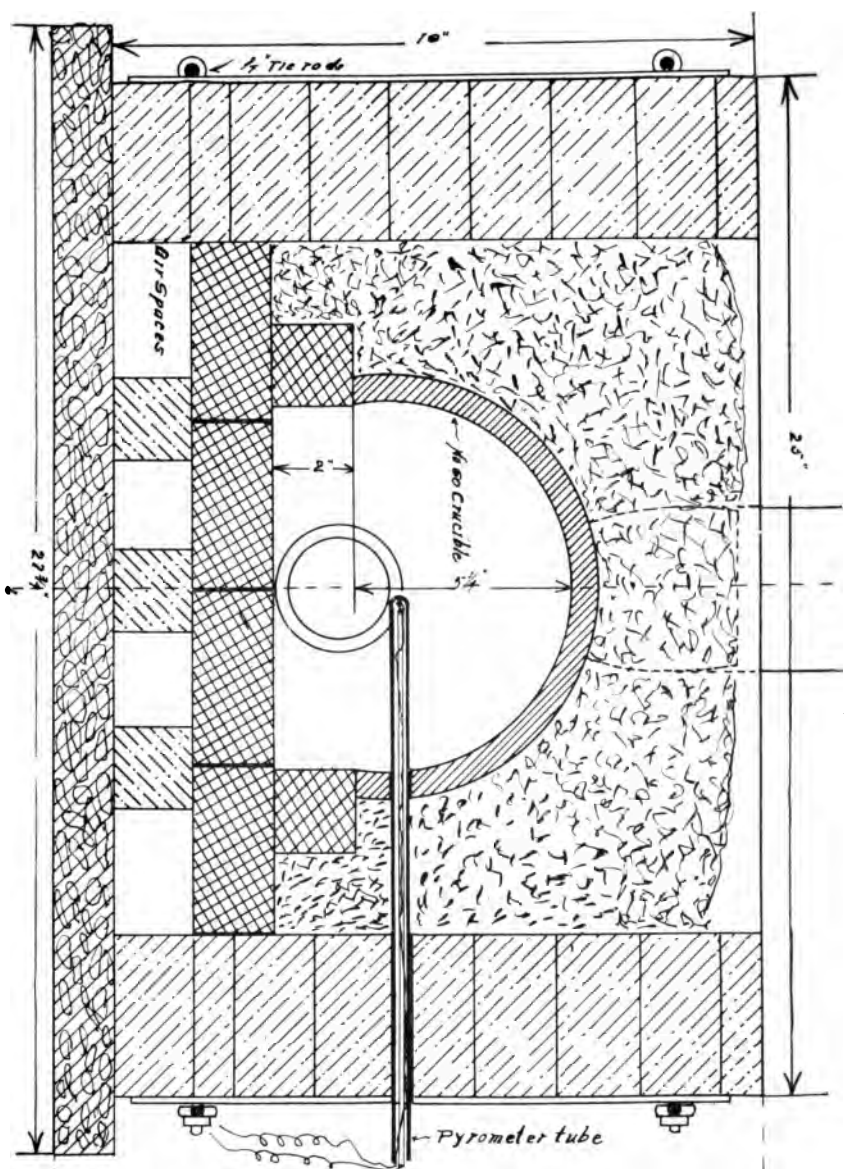
Preparation of the Cement for Testing.—The cement clinker was crushed and ground in the Braun grinder, to pass a 150 mesh screen thoroughly mixed and was ready for testing. Some samples of it were stored before testing, others, tested without storing.



LONGITUDINAL SECTION

FIG. 8.





CROSS SECTION
Fig 9





PART IV.
EXPERIMENTAL TESTS ON BLACK HILLS
CEMENT.

MARK EHLE, JR., E. M.



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Testing.

MARK EHLE, JR., E. M.

In testing the Portland Cement manufactured at the State School of Mines the object was to determine its suitability as a constructive material, within limitations established by the American Institute of Civil Engineers, through a committee appointed by that body in 1903. To this end all methods of procedure were in accordance with the specifications by them adopted.

The properties examined and reported herein include the following: (1) Color; (2) Specific Gravity; (3) Activity; (4) Soundness; (5) Strength.

Color:—The color of a cement powder indicates little or nothing relative to its cementitious value and is of importance only when the cement is to be used in connection with exposed portions of a structure, a uniform shade being desired. All the cement made at the School of Mines was of the greenish gray shade, characteristic of many commercial Portlands.

Specific Gravity.—According to the reports of the committee above mentioned, the determination of the Specific Gravity of a cement powder gives the best and quickest test for underburning or adulteration; the Specific Gravity of an underburned or impure product being usually lower than for the normal article. In the case of the samples herein reported the main interest lies in a comparison with well established figures, which for standard brands vary from 3.10 to 3.25. The tests for Specific Gravity were made with



the aid of the simple apparatus designed by LeChatelier, and shown in the accompanying Fig. 1. It consists of a flask (D) having a capacity of 120 cubic centimeters (72.32 cu. in.), the neck of which has a diameter of about 9 millimeters (0.35 in.) and is expanded into a bulb (C) about midway of its length. The volume of this bulb between two marks at (E) and (F) is just 20 cubic centimeters, (1.22 cu. in.) and graduations on the tube, reading to tenths of a cubic centimeter, are continued upward from (F). The small funnel (B) has a tube long enough to extend just below (F).

In determining the Specific Gravity of a cement powder, the flask is filled with kerosene (free from water, to the point (E)). The sample, having been first thoroughly dried and brought to the temperature of the liquid in the flask, a portion equal to about 64 grams (2.25 oz.) is carefully weighed out and introduced into the flask through the funnel (B). The level of the liquid is thus raised to some division on the graduated neck and this reading added to 20 gives the total volume displaced by the powder.

The Specific Gravity is then obtained from the following formula:

$$\text{Specific Gravity} = \frac{\text{Weight of Cement}}{\text{Displaced Volume}}$$

During the test, the flask is kept immersed in water in the jar (A), in order to avoid variations in the temperature of the liquid it contains.

Activity.—By this term is meant the rate of hardening of a cement after being made, with water, into a paste and allowed to stand undisturbed. As the degree of plasticity of the paste very much effects the rate of hardening, it becomes necessary to mix all samples to a uniform or, as it is termed, normal consistency, in order to establish a basis from which to make observations. The test for activity therefore in-

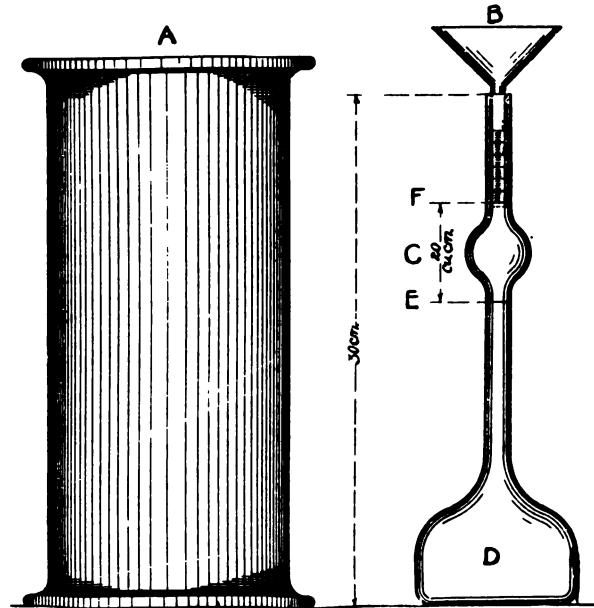


FIG. 1

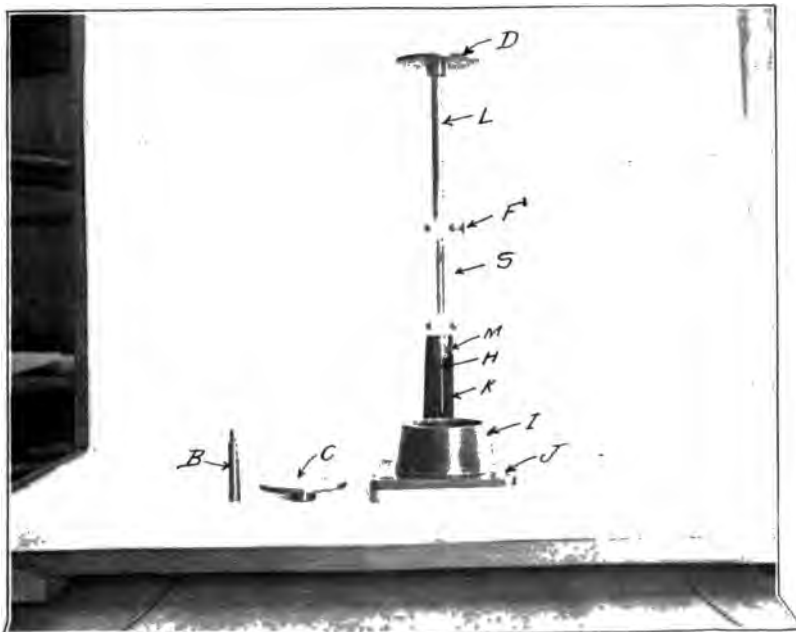


FIG. 2



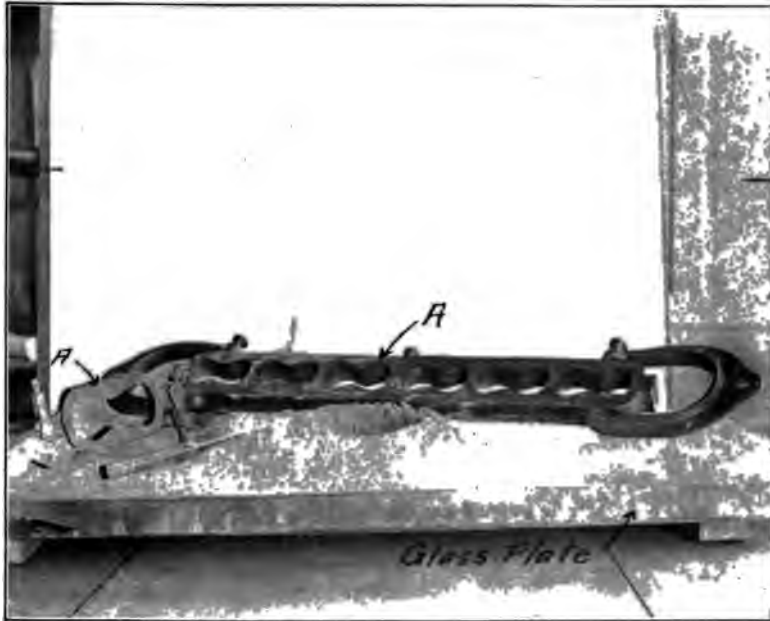


FIG. 3

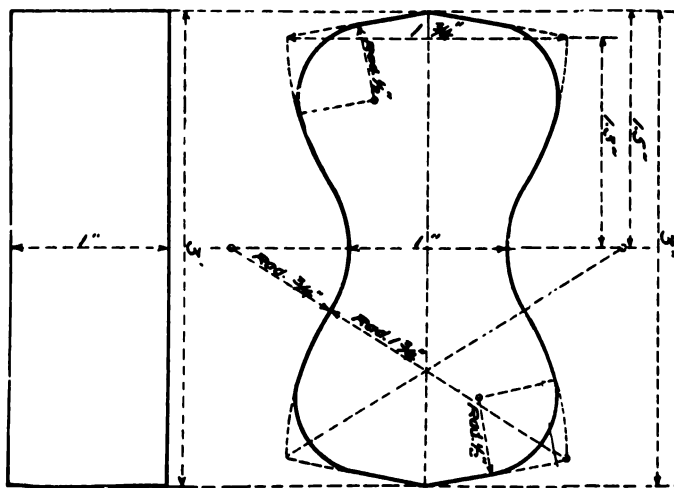


FIG. 4





cludes, for each sample, a preliminary test for normal consistency.

The methods employed in these determinations involved the use of the "Vicat Needle" apparatus its suitability as to constructive material, within limits shown in Fig. 2, and described as follows: (L) is a movable rod which may be adjusted vertically and held in any position by the set screw (F). An indicator attached to this rod moves over the scale (S) which is graduated to millimeters and attached to the frame (K). Into the lower end of the rod may be inserted either the cylinder (B), 1 centimeter in diameter or the needle (H) one millimeter in diameter, the set screw (M) securing either piece in place. Two interchangeable caps, (C) and (D) of different weights are provided and suitably marked, one for use in connection with the cylinder and the other with the needle; the combination of cap, rod and needle, assembled as shown, weighing just 300 gramms (10.58 oz.) which is also the weight of the combined cap, rod and cylinder. A conical rubber ring (I), 7 centimeters (2.76 in.) in diameter at the base and 4 centimeters (1.58 in.) high rests on the glass plate (J) and retains the paste which is to be tested.

In making the determination for normal consistency, about 500 gramms (17.58 oz.) of the cement powder are quickly worked into a thick paste, formed into a ball with the hands and pressed into the rubber ring through the larger opening, smoothed off and the face covered with the glass plate; plate and ring are then turned over and the smaller opening smoothed off with a spatula or trowel. The paste confined in the ring is then placed under the rod, bearing the cylinder and corresponding cap, the bottom of the cylinder being brought just into contact with the surface of the paste and quickly released. By definition the paste has a normal consistency when the cylinder

penetrates the mass to a depth of 10 millimeters (0.39 in.).

These trial pastes are made up with varying percentages of water until the proper consistency is obtained. In making the test for activity the cylinder (B) is replaced by the needle (H), and the cap (D) replaces (A). The ring is then filled with paste of normal consistency, carefully smoothed off, and placed under the rod. At lengthening intervals of time the needle is brought just into contact with some point of the surface and quickly released. The setting is said to have commenced when the needle ceases to pass a point 5 millimeters (0.20 in.) above the upper surface of the glass and is said to have terminated the moment the needle does not visibly sink into the mass. The two points thus observed are termed the initial and final set, respectively, and the time of each period is to be noted from the instant of first addition of water to the mixture. The time of initial set varies widely in different cements, ranging from 15 minutes to 12 hours and is of great importance in that it marks the time after which no internal disturbance of the mass should occur.

The final set marks the point when real hardening has commenced which hardening process may not be complete for years. The test pieces should in all cases be kept damp or immersed in water during the period of testing.

Soundness.—By this term is meant the ability of the cement to retain its strength and form indefinitely. Any tendency to swell, crack or disintegrate, after the mass has set, indicates failure in this respect.

As unsoundness is frequently caused by the presence in the cement of some active agent such as free lime or magnesia and as the evil effects of these elements would, under normal conditions, not be manifest for a considerable period, it becomes desirable to accelerate their action and by thus noting the behavior of the cement over a relatively short period, under

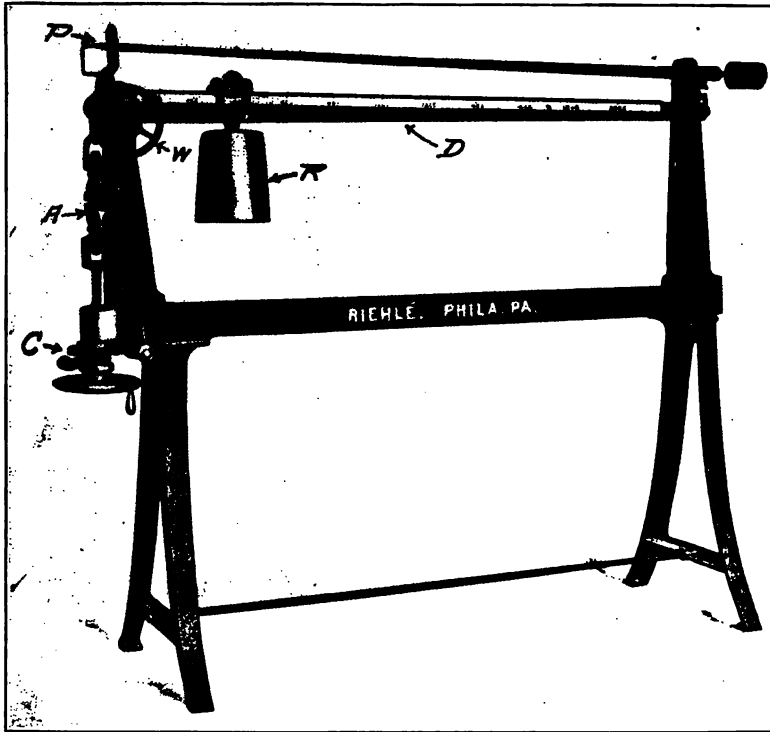
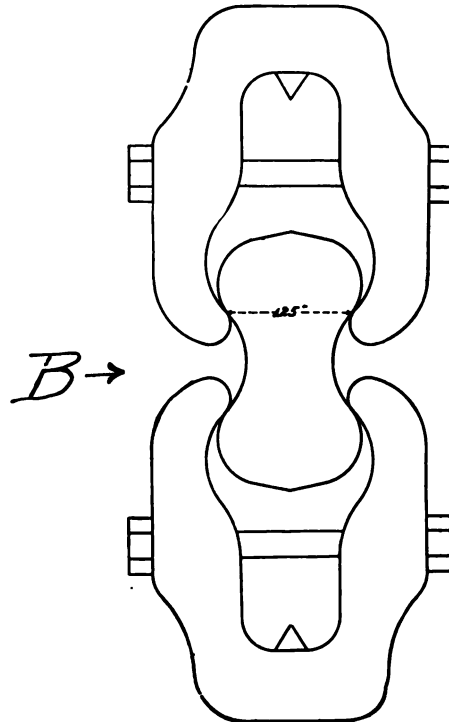


FIG. 5







abnormal conditions, determine what would probably be their action over a long period under normal conditions.

This accelerating action is usually effected by the use of heat, the test being made as follows. From a paste of normal consistency a number of lens shaped patties are moulded on watch glasses, each sample being smoothed out to a thin edge around its circumference. These patties are then set aside in a moist atmosphere until quite hard. These samples, still adhering to the glasses, are then placed in a vessel of water, the temperature of which is gradually raised to the boiling point and maintained there for at least three hours. To pass a satisfactory test the patties should remain intact without any sign of cracking, disintegration or distortion.

Strength.—The tests for strength were made by submitting moulded specimens, having a minimum cross sectional area of one square inch, to a tensile stress sufficient to rupture them, and noting the magnitude of such stress, for the purpose of comparison. On account of the lack of suitable apparatus, no tests of crushing strength were made. Extensive investigation has shown, however, that the resistance in compression may be assumed as about ten times that in tension.

In the case of each batch of cement burned, tests were made on specimens made from the pure or "neat" cement and also on specimens of mortar, composed of certain percentages of cement and standard sand. By standard sand is meant a clean, sharp sand, all of which will pass a twenty mesh and remain on a thirty mesh screen. The effect of age was also considered, specimens being tested at seven and also at twenty-eight days from time of mixing.

The form of mould used in making the briquettes or test pieces is shown at (A), Fig. 3, the samples being retained in the moulds, in a damp atmosphere, until hard, when they were removed and kept under water



until tested. Fig. 4 shows the feature of one of these standard briquettes.

The machine used in making these tests, the property of the School of Mines, is the standard type manufactured by Riehle Bros. of Philadelphia, Pa., and has a capacity of 2000 lbs. It is shown in Fig. 5. In operating, the briquette to be tested is introduced into the clips or jaws at (A) (also shown in detail in Fig. 6). By means of a small hand wheel operating the worm gear at (C), a gradually increasing tensile stress is brought to bear on the specimen, this stress being counterbalanced, through a compound lever, by the rider (R) running on the graduated beam (D), the position of the rider being controlled by the small hand wheel (W), and exact equilibrium being at all times maintained by observing the pointer (P). The stress is increased slowly and uniformly until rupture of the piece occurs, the stress producing it being then read directly, in pounds, from the position of the rider on the beam.

Results.—In all, some thirteen batches of cement were burned and tested, the results obtained from five of them being shown in the following tabular view.

Number of Batch of Cement	Number of Sample	Specific Gravity	Activity or Time of Initial Set	Soundness	Strength in Tension			
					After 7 Days		After 28 Days	
					Neat	3 Pts. Sand 1 Pt. Cem't	Neat	3 Pts. Sand 1 Pt. Cem't
7	4	3.18	11 hours	Perfect	414			
"	6	"	"	"	413			
"	5	"	"	"			540	
"	1	"	"	"			555	
8	1	3.20	10 hours	Perfect	355			
"	3	"	"	"	360			
"	7	"	"	"		145		
"	10	"	"	"		96		
"	5	"	"	"			570	
"	6	"	"	"			592	
"	11	"	"	"				178
"	12	"	"	"				191
9	1	3.25	9 hours	Perfect	459			
"	3	"	"	"	422			
"	10	"	"	"		116		
"	11	"	"	"		107		
"	4	"	"	"			543	
"	2	"	"	"			572	
"	14	"	"	"				191
"	15	"	"	"				205
12	3	3.17	10 hours	Perfect	397			
"	4	"	"	"	358			
"	5	"	"	"		171		
"	6	"	"	"		179		
"	1	"	"	"			560	
"	2	"	"	"			510	
"	7	"	"	"				218
"	8	"	"	"				285
13	1	3.16	10 hours	Perfect	358			
"	2	"	"	"	413			
"	3	"	"	"		184		
"	7	"	"	"		168		
"	3	"	"	"			565	
"	4	"	"	"			670	









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SOUTH DAKOTA SCHOOL OF MINES

Bulletin No. 17

Department of Mining

THE MINING INDUSTRY OF
SOUTH DAKOTA

By

FRANCIS CHURCH LINCOLN

WALTER G. MISER

JOSEPH B. CUMMINGS

Rapid City, South Dakota
February, 1937



Black Hills Gold Mine
6-25-37



Figure 1. The Homestake Mine: The Greatest Gold Mine in the United States.
New Kirk power plant at left, new Ross shaft and Homestake open cut at center. Ellison shaft at right in distance.

Courtesy Black Hills Studios, Inc., Lead

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PART I

MINING IN SOUTH DAKOTA

By

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South Dakota School of Mines



PART I

MINING IN SOUTH DAKOTA

By

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MINING IN SOUTH DAKOTA

By Francis Church Lincoln

1. Importance

During the year 1933, the mines of South Dakota produced useful mineral substances with a value of fifteen million dollars. The annual production for 1934 was more than nineteen million dollars, and in 1935 it had risen to over twenty-two million dollars. Details of the mine productions for 1934 and 1935 are shown in Table One.

Great as these productions were, they alone were not sufficient to make South Dakota one of the leading mining states. In 1934, for example, South Dakota stood but twenty-eighth in annual value of mineral products, according to Minerals Yearbook of the United States Bureau of Mines; and contributed only 0.63% of the total production of the nation. The mining industry of South Dakota is, however, of greater importance than this method of rating indicates, because of certain unique features which it possesses. South Dakota contains the greatest gold mine in the United States,—the Homestake Mine; and is the principal American producer of three unusual mine products,—beryl, lithium minerals, and tantalum ore.

Table One: Annual Mine Productions of South Dakota for 1934 and 1935

Product	1934		1935	
	Amount	Value	Amount	Value
Gold	486,118.97 ozs.	\$ 16,989,858	567,230.20 ozs.	\$19,853,057
Sand & Gravel.	3,863,410 tons	773,559	n	n
Portland Cement.	*412,521 bbls	*598,155	*427,957 bbls.	*667,613
Stone	237,510 tons	497,200	n	n
Coal	**42,907 tons	**77,000	n	n
Silver	99,741 ozs	64,479	151,047 ozs.	108,565
Lime	4,800 tons	52,800	n	n
Feldspar	9,190 tons	30,982	22,099 tons	62,498
Gypsum	3,750 tons	16,250	n	n
Lithium Minerals).....	684 tons	20,480	*638 tons	*24,330
Tantalum Ore.	425 lbs.	168	7,681 lbs.	4,521
Mica	*510 tons	*5,100	344 tons	3,440
Natural Gas.	11,000 M cu. ft.	4,000	8,500 M cu. ft.	2,550
Clay .....	.....	* 2,000	.....	n
Beryl	*25 tons	*875	*60 tons	*1,800
Tin	448 lbs.	234	800 lbs.	452
Rose Quartz.	*11 tons	750	13 tons	850
Lead	0	0	3½ tons	280
TOTAL.....	.....	\$ 19,133,800	.....	.....

Unstarred figures are those of the Mineral Resources Division of the United States Bureau of Mines.

*Estimated by the author.

**Mineral Resources figures with addition of 500 tons valued at \$1000 for production of small mines excluded from Mineral Resources estimate.

n No figures available.

2. Discovery of Gold and Early Placer Mining

Gold was discovered in South Dakota in 1874 by a military expedition under the command of General George A. Custer which was making a reconnaissance of the Black Hills, then a part of a great Sioux Indian reservation. Horatio N. Ross and William T. McKay, prospectors attached to the Custer expedition, found placer gold on French Creek at the present site of the town of Custer late in July, 1874.

News of the gold discovery spread rapidly, and in spite of the presence of hostile Indians and the issuance of military orders forbidding whites entrance to the Hills, several parties of prospectors succeeded in evading both Indians and soldiers and entering the forbidden land. The largest of these was the Gordon party, which consisted of twenty-six men, a woman, and a boy. This prospecting party reached French Creek in December, 1874, built a stockade for protection from Indians, and extracted 70 ounces of placer gold valued at \$20 an ounce, before being ejected by soldiers in April, 1875. This was the first mining operation conducted in South Dakota.

An insistent demand arose for the opening of the Black Hills to prospectors, and the government appointed a committee to negotiate with the Sioux with this object in view. When negotiations failed, the military authorities withdrew their objections to whites entering the Hills, and prospecting was resumed although the Black Hills were not ceded to the United States until September 26, 1876. A gold rush to the Black Hills ensued. Custer in the southern Hills received the first influx of gold seekers, but the placers in that neighborhood proved to be of low value and limited extent, so the prospectors worked northward and eastward and soon discovered the rich placers of Deadwood Gulch and Nigger Hill in the northern Hills and of Rockerville in the eastern Hills. The first placer claim on Deadwood Gulch was located by Bryant, Coder, and Cudney on November 17, 1875; but the

news of this rich strike did not reach Custer till the following spring. Custer then had a population of 11,000, which was quickly reduced to 100. The stampede to the Black Hills continued and the population of Deadwood rose to 25,000 that summer.

The yield of placer gold in South Dakota from 1875 to 1880, has been estimated at from \$6,000,000 to \$8,000,000. About \$4,000,000 of this was produced in the Deadwood District.

3. The Homestake Mine

The first lode claims located in the Black Hills were the Giant and the Old Abe, which were taken up by J. B. Pearson on December 11th, 1875, and later became part of the Homestake holdings. The original Homestake claim was located by Moses Manuel and Hank Harney on April 9, 1876; and was purchased by George Hearst for the Homestake Mining Company in the fall of 1877 for the sum of \$70,000. The adjoining claim on the west, the Golden Star, was purchased at the same time. These claims were fractional claims having a total area of 14 acres or about two-thirds that of a single full lode claim. From this small beginning, the holdings of the Homestake Mining Company have grown until today it owns 602 mining claims aggregating 3,920 acres together with 4,674 acres of land held for water rights and 39,765 acres held for timber. From 1876 to 1935, inclusive, the Homestake Mine received \$302,001,503 cash return from bullion and concentrates shipped after deduction of freight, express, insurance, mint and smelter charges. The dividend payments made by the company have been \$88,020,442.

A mining method has been gradually developed at the Homestake Mine which is particularly well adapted to the local conditions. The orebody is first cut by a series of stopes each extending for 60 feet along the strike and from wall to wall of the deposit,—a distance which may be as great as 400 feet.

Pillars of ore 42 feet in thickness separate the 60-foot stopes. A stope is started by making a cut entirely across its bottom. A timbered gangway provided with chute gates is next constructed across the floor of the cut and waste filling is introduced around it. The stope is then carried upward by shrinkage stoping to



Figure 2.

Courtesy Black Hills Studios, Inc., Lead

The Homestake Gold Mine at Lead

Foundry, shops, engineering office, and fan house at left; Ellison shaft at center; Ross shaft and mine office at right.

within about 25 feet of the level above. The interval between levels is 100 feet in the upper part of the mine and 150 feet in the lower. During shrinkage stoping, the miners stand upon the broken ore, enough being drawn off regularly through the chute gates into the gangway to keep the ore away from the back and provide room for the miners to work. When shrinkage stoping is completed, the broken ore remaining in the stope is all drawn off, and the stope is filled with waste rock or mill tailings. The crowns of the stopes and the pillars between them are later mined by the square-set timbering system, the square sets being filled with waste. Tramming is done mainly by compressed air haulage; and ore is hoisted in the Ellison and Ross shafts.

The ore removed from the Homestake Mine is treated by the amalgamation and cyanide processes which extract most of its gold and silver content. Amalgamation is conducted in the South Mill which has a capacity of 4,000 tons per 24 hours and is equipped with 180 stamps, 10 rod mills, 2 ball mills, 4 tube mills, 12 Clark-Todd amalgamators, and 1,180 square feet of amalgamating plates. Cyanidation is carried on in two sand plants and one slime plant.

The new 13x19-foot 3-compartment Ross shaft, which was begun in December, 1932, had reached the 3,650-foot level in 1935 and is to be sunk to 5,000 feet ultimately. The new Kirk steam-electric power plant with a capacity of 16,000 kva went into operation in 1935. During the year 1935, 1,379,163 tons of ore were milled realizing an average of \$13.915 per ton, with a total revenue from bullion of \$19,191,013.19.

4. Other Precious Metal Mines

From 1876 to 1935, inclusive, South Dakota produced gold to the value of \$358,020,705 and silver to the value of \$6,742,852; making a total precious metal production of \$364,645,450, according to the Mineral Resources Division of the United States Bureau of Mines. While the major part of this production was made by the Homestake Mine and the mines now consolidated with it, important contributions have been made by other Black Hills mines. The bullion production of the Homestake Mine

during this period was valued at \$301,019,015, so other mines produced \$63,744,542.



Figure 3. Mine and Mill of the Bald Mountain Mining Company at Trojan.
The second largest gold mine in the Black Hills.

In the year 1935, there were 15 lode mines and 199 placers producing gold and silver in South Dakota, according to Mineral Resources. These mines produced gold valued at \$19,853,057 and silver valued at \$108,565. The principal producers, aside from the Homestake Mine, were the Bald Mountain Mining Co., the Canyon Corporation, the Monarch Mine, the New Deal Mining Co., and the Comet Queen Mine in Lawrence County; the Golden Slipper Mine and Western Bell Mine in Pennington County; and the Palmer, Dorothy Van, Dickey and Grand Hills Mining Co. placers in Custer County.

Table Two gives the names and locations of South Dakota gold lode mines active during 1936 and states the type of work conducted at each.

Table Two: Precious Metal Lode Mines Active in 1936

Mine or Company	Location	Type of Activity
CUSTER COUNTY		
Golden Crown Mine	Near Custer	Examined for RFC loan
Spokane Silver & Lead Co.	Spokane	Examination
Turk Mine	Near Custer	Examined for RFC loan
Wild Rose Mine	Near Custer	5 men employed on exploration
LAWRENCE COUNTY		
Anaconda Gold M.&M. Co.	Roubalx	50 men developing Clover Leaf Mine and running 10-stamp mill
Anchor Mine	Near Deadwood	Examined for RFC loan
Annie Creek Mining Co.	Near Lead	Development
Bald Mountain Mining Co.	Trojan	300 men mining and operating 300-ton cyanide plant
Black Hills Exploration Co.	Near Lead	Diamond drilling
Black Hills Mining Corp	Near Deadwood	20 men mining and operating 25-ton cyanide plant at Monarch Mine
Canyon Corporation	Near Deadwood	85 men mining and operating 25-ton cyanide plant at Maitland Mine
Deadwood Gold, Inc.	Near Deadwood	5 men employed on exploration of Golden Crest Mine
Echo Mine	Near Lead	Examined for RFC loan
Frerichs Mine	Near Deadwood	Examined for RFC loan
Gilt Edge Mines, Inc.	Near Deadwood	50 men employed on construction and development
Golden Mining Co.	Near Deadwood	Examination and development
Golden Reward Cons. G. M. & M. Co.	Terry	Examination
Homestake Mining Co.	Lead	2,000 men mining and operating 4,000-ton amalgamation and cyanide plants
Mascot Mine	Near Deadwood	Examination
Montana Mine	Near Rochford	2 men employed on exploration
Pennsylvania Mine	Near Deadwood	Examination
S. R. Smith Group	Near Deadwood	Examination
PENNINGTON COUNTY		
Central Black Hills Gold Mine	Near Hill City	Development
Empire Gold Mines, Inc.	Near Hill City	35 men mining and operating 75-ton amalgamation and flotation mill at Golden Slipper and Forest City mines
Gold Hill Mine	Near Hill City	Examined for RFC loan
King of the West M. Co.	Near Rochford	28 men mining and operating 50-ton cyanide plant
Mines Finince & Dev. Shares, Inc.	Keystone	10 men unwatering and exploring Bismark Mine, and RFC examination
New Eldorado Mine	Near Hill City	6 men employed on exploration
Standby Mine	Rochford	Examination
Western Bell Mine	Near Hill City	Examination

The smaller gold mines are worked mainly by open stope mining methods. Occasionally, the conditions are favorable to shrinkage stoping and that method is employed, while in heavy ground square sets are sometimes found necessary for support.

Small scale placer gold mining operations are conducted on many streams in the Black Hills. Pans, rockers, and short sluices are employed for the extraction of the placer gold. The only large placer mining operation in 1936 was that of the Grand Hills Mining Company which operated a dragline excavator on French Creek near Custer during the summer and recovered the placer gold by centrifugal concentration.

At present, the silver output of South Dakota is produced entirely as a byproduct of gold mining, but in the past considerable silver was obtained from lead-silver ores.

5. Sand and Gravel Mining

More sand and gravel than gold ore is mined in South Dakota at the present time, and the value of the sand and gravel produced annually ranks next to that of the gold. Further interesting comparisons may be made between these two main branches of the South Dakota mining industry. South Dakota is credited with a production of 3,863,410 tons of sand and gravel having a value of \$773,559 in 1934 by Mineral Resources. This sand and gravel had an average value of 20 cents per ton as compared with one of \$1,020,810 per ton for gold. Only about 17 tons of gold were produced in 1934, while more than two hundred thousand times as much sand and gravel mined that year yielded less than one-twentieth the value. The gold was extracted from 1,520,669 tons of ore and tailings, or from less than one-half the amount of sand and gravel excavated that year. The gold all came from the Black Hills region, but the sand and gravel came from pits scattered throughout the state.

Records of sand and gravel production in South Dakota were not published by Mineral Resources prior to 1909. In the 26 years from 1909 to 1934, inclusive, the state produced 32,421,289 tons of sand and gravel with a value of \$8,442,450. This total recorded production is exceeded only by those of gold and of stone.



Figure 4. Mining Sand and Gravel at the Oral pit of the Reitz & Crites Sand Company.

Most of the sand and gravel pits are operated on a small scale and in an unsystematic manner. In the eastern part of the state there are several large pits in operation which are provided with excavating machinery and have plants consisting of screens, washers, and crushers. The largest operations in western South Dakota are those of the Reitz and Crites Sand Company at Oral and at Hermosa. Mining at Hermosa is done with a power shovel, and at Oral with a dragline excavator; and there are screening and washing plants at both pits.

6. Portland Cement Manufacture

South Dakota has had two distinct periods of portland cement production. A plant at Yankton manufactured portland cement from 1891 to 1909, and a plant at Rapid City went into production in 1925 and is still making cement. The total production of portland cement in South Dakota for these two periods, covering the time from 1891 to June 30, 1936, was approximately 6,955,446 barrels worth about \$9,793,276. The value of the present annual production of portland cement is a little less than that of sand and gravel, making portland cement manufacture third among the mineral industries of South Dakota.

The cement plant at Yankton was erected in 1889-1890 by the Western Portland Cement Company. It originally had a capacity of 250 barrels per day, but in 1904 the plant was remodeled and the capacity increased fivefold. The raw materials employed in making the cement were Niobrara chalk and Pierre shale, both of Cretaceous age. Impurities in these raw materials made selective mining necessary, and the plant was forced to shut down in 1910 as a result of competition with large new cement plants to the eastward. The total production of the Yankton mill was about 1,913,738 barrels with a value of about \$3,032,164.

The cement plant at Rapid City was erected in 1923-1924 by the State of South Dakota and has been shipping a high grade of portland cement since January 26, 1925. The plant has a capacity of 2,000 barrels per day. The raw materials used are Minnekahta limestone of Permian age and Pierre shale of Upper Cretaceous age. The limestone is mined from a hillside quarry near the mill. Blastholes are bored by an electrically-operated churn drill and the broken limestone is loaded into cars for transportation to the mill by a steam shovel using gas for fuel. The shale quarry is located on the railroad 8 miles easterly from the cement mill. The shale is mined and loaded upon railway cars by a diesel shovel. From January 26, 1925 to June 30, 1936, the South Dakota State Cement Plant sold about 5,041,708 barrels of cement valued at about \$6,761,512.

7. Stone Quarrying

The value of the stone produced in South Dakota in recent years has not been so great as that of the sand and gravel or of the portland cement, but the total amount of stone quarried in the state has exceeded in value that of any other mine product save gold. Sandstone is highest in value of total production, followed by granite and limestone; but granite has led in recent annual productions, followed by limestone and sandstone,—as may be seen by Table Three.

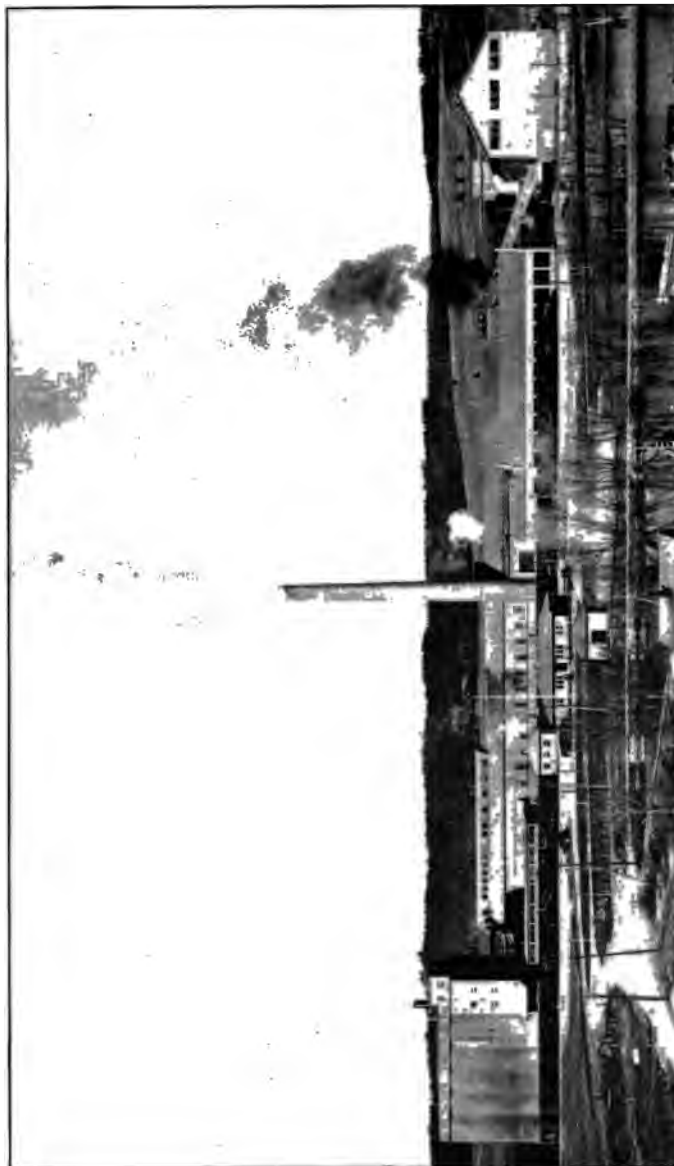


Figure 5. The South Dakota State Cement Plant at Rapid City. Photo by Rise Studio, Rapid City.

**Table Three: Stone Production of South Dakota
Quarries**

Stone	Total Production		Annual Production 1934	
	Years	Value	Tons	Value
Sandstone	1884-1934	\$ *6,021,869	70,310	\$ 92,816
Granite	1890-1934	*4,459,750	7,590	243,568
Limestone	1893-1934	1,386,563	87,120	110,684
Miscellaneous	1921-1934	*228,033	72,490	50,132
Total.....		\$ 12,186,215	237,510	\$ 497,200

Unstarred estimates are those of the Mineral Resources Division.

*Figure given includes estimates or revisions by the author.

A beautiful mahogany granite of monumental quality is quarried in the northeastern part of South Dakota. This granite is of pre-Cambrian age and outcrops south of Big Stone Lake between Milbank, South Dakota, and Ortonville, Minnesota. The largest granite producer in this area is the Robert Hunter Granite Company, Inc., of Milbank. This company cuts the granite into large blocks with a channel bar and loosens the blocks by firing light charges of explosives introduced into lift holes beneath the blocks. The large blocks obtained in this manner are split into saw blocks by wedging from drill holes, and the saw blocks lifted by a derrick to cars which transport them to a saw shed.

Limestone is quarried in the Black Hills and used mainly for crushed stone although some is sold for riprap, some for sugar refining and some for minor miscellaneous purposes. The limestone used in the manufacture of portland cement and of lime is not included in Table Four. The limestone quarried is the Minnekahta limestone of Permian age, the same as that quarried for making portland cement. The quarries are all open pits located on hillsides.

Sandstone is quarried in the Black Hills, and quartzite,—which is classed with sandstone by Mineral Resources,—is quarried in the southeastern part of South Dakota. The Black Hills sandstone is used for building stone. It has been quarried



The Evans Sandstone Quarry at Hot Springs.

Figure 6.

extensively in the southern Black Hills for about fifty years. The sandstone quarried there is the Dakota sandstone of Upper Cretaceous age. The Lower Cretaceous Lakota sandstone has been quarried in the vicinity of Rapid City, Sturgis, and Spearfish; and the Unkpapa sandstone of Upper Jurassic age has been quarried near Buffalo Gap.

The pre-Cambrian Sioux quartzite of southeastern South Dakota has been quarried extensively at Sioux Falls, Dell Rapids, and Spencer. It is sometimes called "Sioux Falls Granite", and also "jasper". While formerly quarried for building stone and paving blocks, it is now mainly produced for crushed stone.

8. Coal Mining

In 1895, 200 tons of coal worth \$400 were taken from a mine located near Edgemont in the Black Hills, according to Mineral Resources. This is the first recorded production of coal from South Dakota, but it is possible that coal was mined in the northwestern part of the state at an earlier date.

In 1934, 42,407 tons of lignite coal valued at \$76,000 were produced in South Dakota from mines other than wagon mines producing less than 1,000 tons a year. This production was made by 21 mines employing 91 men, about half the production coming from a single mine. The South Dakota State Planning Board report estimates that from 1913 to 1934 there were 10 small mines working each year and producing 50 tons a year apiece, which seems a very conservative estimate. The total production of lignite coal in South Dakota from 1895 to 1934, inclusive, has been about 477,290 tons with a value of about \$1,070,392.

Most of the coal mined in South Dakota comes from open pits known as coal strippings. A small amount is extracted from underground workings by hand methods and a small amount by machine. In 1934, 10 of the 21 commercial coal mines in South Dakota were strip mines, and these 10 produced 85.2% of the total production of the state.



Figure 7. Mining Lignite Coal on the Smith Property near Bison.

9. Lime Industry

In western South Dakota, the Minnekahta limestone of Permian age, was quarried and made into lime for local use prior to 1888. Lime was also produced at an early date in eastern South Dakota, the limestones burned being boulders from the glacial drift and the harder portions of the Niobrara chalk of Cretaceous age. No lime production was recorded by Mineral Resources, however, until the year 1896, when 160 tons were produced. The production rose to more than four thousand tons in 1905, and has ranged from 2,800 to 5,600 tons annually since that date. The total recorded lime production of South Dakota from 1896 to 1934, inclusive, was 144,719 tons with a value of \$1,304,437.



Figure 8. Lime Plant of the Black Hills Marble Quarries Corporation at Rapid City.

There are three lime plants in operation in South Dakota at the present time. The Black Hills Marble Quarries Corporation supplies hydrated lime for building purposes and occasionally lump lime for metallurgical use. Limestone is mined from a hillside quarry in the Minnekahta limestone near Rapid City and trammed by hand to gas-fired kilns. The lime to be hydrated is first crushed in a pot crusher. After hydration, the product is cleaned in a Sturtevant air separator. The plant of the Black Hills Lime Company at Pringle supplies most of the lime used in the gold mills of the Black Hills. Its quarry is in the Pahasa-pa limestone of Mississippian age. The Utah-Idaho Sugar Company at Belle Fourche makes lime for its own use in sugar refining. This company does no mining itself but purchases limestone from various quarries in the Minnekahta limestone.

10. Gypsum Industry

Gypsum for making plaster for local use was first mined in the Black Hills in the early eighties. The first recorded production was 7½ tons in 1884. The annual production increased and reached 5,800 tons in 1892 when the first large gypsum plant went into operation. From 1892 to 1930, the production was large but irregular. A considerable drop in production took place in 1931 after the sale of the Blackhawk plant to the United States Gypsum Company and its shutting down to prevent competition with the Piedmont plant of that company. The total production of gypsum in South Dakota from 1884 to 1934, inclusive, was about 279,449 tons with a value of about \$1,650,525.

The Piedmont plant of the United States Gypsum Company is the only gypsum plant at present in operation. The principal production of this plant at the present time is raw gypsum which is sold to the State Cement Plant for use in the manufacture of portland cement. The gypsum quarry is in the Spearfish formation which is of Triassic age.

11. Pegmatite Mining

Pegmatite dikes occur in the Algonkian metamorphic rocks which outcrop in the central Black Hills, and have long been the object of mining operations. The mine products, feldspar, lithium minerals, tantalum ore, mica, beryl, tin, and rose quartz,—shown by Table One to have been produced in 1934 and 1935,—were all derived from these dikes. The value of the pegmatite minerals mined in 1934 was \$58,499; and in 1935, \$97,891. Other products of the pegmatite dikes which have contributed to South Dakota productions in past years, are tungsten ore, andalusite and sillimanite, and pollucite. The total value of the pegmatite minerals produced from 1879 to 1935, inclusive, was about \$2,659,731. Details of this production will be found in Table Four.

Mica was the first pegmatite mineral mined and has contributed more than half the total value of the pegmatite minerals produced to date. Later, lithium minerals became an important feature of production, and recently feldspar has led in annual production value. The mining of these three important pegmatite minerals will be described in the following three sections. Comparatively little tungsten ore has been derived from deposits associated with the pegmatite dikes, but a large amount of tungsten has come from another source, so tungsten mining is likewise described in a separate section. There remain for discussion in this section the minor pegmatite products,—tin ore, tantalum ore, rose quartz, beryl, andalusite and sillimanite, and pollucite.

**Table Four: Mineral Production from Black Hills
Pegmatites (Concluded)**

Year	Mica	Rose Quartz	Tin	Tung- sten	Andalusite and Sillimanite	Polu- cite
	Value	Value	Pounds	Value	Tons	Value
1879-1901	\$ 600,000	\$ 3,150	206,665	\$ 43,871		
1902-1912	567,400	20,611	107,214	32,482	\$ 1,500	
1913	12,609	162	1,500	660	3,000	
1914	7,504	404	Small production	400		
1915	10,914	350	1,805	722	1,425	
1916	59,770	467	240	108	12,000	
1917	11,008		22,196	8,275	1,000	
1918	10,464		240	200	2,000	
1919	5,245	700	0	0		
1920	3,875		12,000	6,000		
1921	2,200	335	0	0		
1922	4,980		0	0		
1923	6,480		0	0		
1924	9,267		0	0		
1925	19,427		0	0		
1926	21,500		0	0		
1927	26,000		325	200		
1928			4,000	2,000		\$ 2,000
1929	9,513	7,800	500	200		
1930			315	100		
1931	2,400		189	50		
1932	1,949		1,000	220		
1933	2,400		225	88		
1934	6,650	750	448	234		
1935	3,440	850	800	425		
Totals	\$ 1,405,100	\$ 35,579	359,662	\$ 95,862	\$ 21,325	\$ 2,470
					66 \$	\$ 2,000

The tin of the Black Hill occurs in the form of the oxide, cassiterite, which is found in pegmatites, in quartz veins associated with pegmatites, and in placers derived from tin-bearing pegmatites and quartz veins. Cassiterite was identified in gold dust from the northern Hills as early as 1876, and was discovered in the southern Hills the following year; but no attention was paid to it until it was discovered in place at the Etta Mine in the southern Hills in 1883. A tin boom ensued. Many small companies were formed, and one large English company, the Harney Peak Tin Mining, Milling, and Manufacturing Company. This company eventually secured control of most of the tin-bearing ground in the southern Hills and was the principal producer for this first mining period, but collapsed and went into the hands of a receiver in 1894. A little production was also made from the northern Hills during this period, and, indeed, the first commercial production of tin in South Dakota appears to have been from the placers of Bear Creek and Sand Creek in the northern Black Hills in 1884. A non-productive period of seven years followed the collapse of the Harney Peak tin boom. Production began again in 1901, and continued irregularly through 1920; the principal production coming from the northern Hills during the first part of this period and from the southern Hills during the last part. A non-productive period of six years ensued, but beginning in 1927 small amounts of placer tin have been produced annually from placers in the northern Black Hills. The total production of tin in the Black Hills from 1884 to the present time has been about 180 tons valued at less than one hundred thousand dollars. This tin was mined from lode tin mines developed by shafts, from open cuts, and from placers.

Columbite, an ore of tantalum and columbium, has been produced in small quantities as a byproduct of other kinds of pegmatite mining since 1918. The principal producer of columbite, and the only one which might be considered a columbite mine, is the Beecher Lode south of Custer which belongs to Collingwood and Greene. Amblygonite, a lithium mineral, has been produced from this property to a greater value than columbite, and a little mica and beryl have also been mined. In the past, the mine was operated as an open cut, but at present a modification

of the glory-hole mining method is employed. The broken ore is sorted in the open cut, and the waste drawn off through a chute into a car in the tunnel below and trammed to the waste dump. The total production of columbite to date has been about 44 tons valued at about sixty thousand dollars. About one-half of this columbite came from the Beecher Lode.

Rose quartz is found in many of the pegmatite dikes and in some instances has a very beautiful color which has created a demand for it all over the world. The most important rose quartz producer has been Scott's Red Rose Mine near Custer. This mine is an open cut in which the rose quartz is blasted from the face and sorted by hand. The total value of the rose quartz mined in the Black Hills to date is over thirty-five thousand dollars.

Beryl, an ore of the metal beryllium, has been mined from the pegmatites as a byproduct of other mining and shipped intermittently since 1914. Total shipments through the year 1934 have been about 476.5 tons with a value of \$22,528. The principal producers have been the Peerless Mica Mine, the Ingersoll Mine, the previously described Beecher Lode, and the Beryl Mica Lode.

Andalusite and sillimanite occur as replacement deposits in the Algonkian schist, more or less directly associated with the pegmatites. The ore occurs in irregular bunches and has been mined unsystematically from surface pits, and trenches. Sixty-six tons with a value of \$2,470 were produced from 1924 to 1932, inclusive.

Pollucite, an ore of caesium which was formerly in demand, occurs in the Tin Mountain Mine near Custer belonging to the Maywood Chemical Works of Maywood, New Jersey. A carload of pollucite valued at \$2,000 was shipped in 1928.

12. Mica Mining

Mica was first mined in South Dakota at the Crown Mine near Custer in 1879. A little later, the New York, Lost Bonanza, Climax, and other smaller mica mines, were opened in the Custer district; and the Peerless and smaller mines in the Keystone district. Up to July 1st, 1884, these mines produced 124,640 lbs.

of sheet mica valued at \$442,589. After that, the production declined, due to competition with cheap Indian mica, and remained low till 1907.

The New York, White Spar, and Crown mica mines in the Custer district were reopened in 1906 by the Westinghouse Electric & Mfg. Co. Intensive mica mining ensued which resulted in placing South Dakota second only to North Carolina as a mica-producing state. The average annual production from 1907 to 1911 inclusive was about a hundred thousand dollars. The New York was the largest Westinghouse mine. The mica at that mine occurs in a pegmatite dike forty feet in width, dipping at 50 degrees, and having its mica content greater near the walls. The mine is developed by a vertical shaft which cuts the dike between the 100-ft. and 200-ft. levels, and crosscuts to the dike on the 100-ft., 200-ft., and 300-ft. levels. Open overhand stopes 6 ft. in width were carried up on the rich mica shoots near the foot and hanging walls of the dike. Holes were drilled about 7 ft. deep and loaded lightly to minimize injury to the mica books when blasting. Mica was sorted from waste underground and most of the waste disposed of as filling. Separate chutes were provided in the stopes for the mica, and on arrival at the surface the cars of mica were trammed to a trimming and grinding house.

The Westinghouse mica mines were shut down in 1911, and a period of low mica production ensued which has continued up to the present time. The average annual production during this period has had a value of about ten thousand dollars; and has consisted mainly of scrap mica, whereas that of the earlier years was largely sheet mica. The total value of the mica produced from 1879 to 1935, inclusive, was \$1,405,100.

The only mine which is at present operated chiefly for mica is the Peerless Mine of the Keystone Feldspar and Chemical Company, situated at Keystone. At this mine, the pegmatite at a schist contact is enriched with mica for a thickness of 15 to 18 ft. The mine is worked as an open cut; drilling and blasting being alternated with sorting and cobbing. Sinking drills put down holes about 9 ft. deep with a 4-ft. burden which are loaded with about 10 sticks of 40% gelatin dynamite. Beryl, columbite, am-

blygonite, and soda feldspar, are produced at the Peerless Mine as byproducts of mica mining.

13. Mining Lithium Minerals

Four of the pegmatite minerals have been mined for their lithium content,—spodumene, amblygonite, lepidolite, and lithiophilite-triphyllite. Attention was first called to the possible use of spodumene as a source of lithium by Dean McGillicuddy of the South Dakota State School of Mines in 1895, and a trial shipment was made from the Etta Mine near Keystone that year. During the next few years, shipments were made from the Etta and other mines in the Keystone district and the Palmer Gulch Mine in the Hill City district. These shipments made South Dakota the greatest lithium mineral producer in the country, a position which she maintains at the present time, although there have been a few years in the past when her production has been exceeded by that of California or New Mexico.

Amblygonite was first mined in 1905, and of recent years its production has been about equal to that of spodumene. A little lithiophilite-triphyllite was shipped in the early days; and small shipments of lepidolite have been made from time to time throughout the period of lithium mineral mining. The total production of lithium minerals from 1895 to 1935, was 19,347 tons having a value of \$664,475.

The Etta Mine of the Maywood Chemical Works is the greatest lithium mine in the United States. The lithium mineral in this mine is spodumene, which is found scattered through the main mass of a pegmatite knob in crystals which vary in length from a few inches to thirty or forty feet. When exposed in the open cut, these crystals bear a strong resemblance to sticks of timber, and for this reason are called "logs" by the miners. A single large log may contribute an entire carload of spodumene to the production of the mine. The glory-hole mining method is employed, in combination with an unusual method of underground sorting. Raises are put up from a tunnel to the surface and enlarged into glory holes at their upper ends. Sinker drills put in holes 8 to 9 feet deep, spaced 5 to 6 feet apart, and carrying 5 to 6 feet of burden. These are loaded with 5 or 6 sticks of

40% gelatin dynamite and fired with fuse and No. 6 caps. The broken material is sorted by hand as it runs from chutes in the tunnel. Two cars are placed at a chute, the waste running into one and the spodumene being picked out and thrown into the other.

14. Feldspar Mining

Feldspar mining in the Black Hills began in 1923 when the Keystone Feldspar & Chemical Co. shipped 150 tons. Shipments increased rapidly, and the feldspar production has exceeded mica production in value since 1926 and lithium mineral production since 1931. In 1935, the feldspar production had a higher value than that of all the other pegmatite minerals mined. The total production of feldspar from 1923 to 1935, inclusive, was 81,402 tons valued at \$350,675. This value is for the raw feldspar, but a large part of the feldspar mined is ground before shipment.



Figure 9 Mining Feldspar at the Mahnke Pegmatite Property near Custer.

Two feldspar grinding plants are in operation at the present time. The plant of the Consolidated Feldspar Corporation at Keystone was built in 1929 and depends mainly upon the Hugo Mine for its supply; while that of F. E. Schundler & Co. at

Custer was built in 1936 and is obtaining its supply mainly from the Rock Ridge and Wilhelm properties. A third big feldspar producer is the Abingdon Sanitary Mfg. Co. which since 1928 has been mining feldspar at the White Elephant Mine near Pringle and shipping it to its own grinding plant at Abingdon, Illinois. Feldspar is also produced as a byproduct of mines whose principal product is mica, a lithium mineral, or some other useful pegmatite mineral; and from a number of small mines in which it is the chief product. All of the feldspar mines are open cut mines.

15. Tungsten Mining

Tungsten ore was discovered in the southern Black Hills as early as 1883, and may have been discovered at the Comstock Mine in the northern Hills even before that time. Production began on a small scale in the southern Hills in 1898 and in the northern Hills in the following year; but prior to 1915 only about 300 tons of concentrates and high grade ore valued at about \$25,000 had been produced. From 1915 to 1919, inclusive, tungsten ore to the value of \$1,131,879 was produced, more than two-thirds of this coming from the Homestake tungsten mine in the northern Hills. Production then ceased until 1926 when the Homestake Mining Company again produced tungsten ore. From 1926 to 1929, the production of the Homestake mine was about \$164,158. The total production of tungsten ore in South Dakota has therefore been about \$1,321,037.

Only \$21,325 of the total tungsten production was contributed by the quartz veins associated with the pegmatites, as indicated on Table Four. The mines on these veins were underground mines. The major part of the production came from replacements in the Deadwood formation of Cambrian age. The principal mines in this formation were the Homestake, the Wasp No. 2, and the Bismarck. These mines were open cut mines.

The only tungsten mine at present active is the Good Luck property of Arthur Wabel near Hill City which made a small production in the past and is now being cleaned out and having its mill repaired under a lease to Floyd H. Elliott and Dr. Townsend.

16. Minor Products of the Mines

A considerable amount of lead in the form of argentiferous galena was mined in the Black Hills in the early days. The earliest important production was made at Galena where a smelter and pan amalgamation plant were erected in 1903 and operated until 1891. In 1885, rich silver-lead ores were found near Carbonate and the Iron Hill Mine was an important producer for several years. From 1898 to 1900, the Spokane Mine near Keystone produced considerable lead and silver. The total production of lead up to 1902 was estimated by Dr. O'Harra to have had a value of \$400,000. Since that time, there have been small productions of lead from the Galena district, the Spokane Mine, and elsewhere, but the total amount has been only about one-tenth the early production. There is no mine in the Black Hills which is chiefly valuable for its lead content.

Pyrite was mined in considerable quantity for use in smelting gold ores in the days when smelters were active in the Black Hills. Drs. Connolly and O'Harra have estimated the value of the pyrite mined at \$130,000.

Bog iron ore occurs in the neighborhood of Rochford. Small quantities of this ore were used as a flux in the early days by local smelters, and in 1893 and 1894, 165 carloads were shipped to the big smelters at Omaha and Kansas City. A paint mill was erected at Custer to utilize the bog iron about 1901, and produced some six thousand tons before it burned down. A renewal of activities in 1925 resulted in the shipment of five hundred tons. In all about 11,450 tons of bog iron ore have been shipped with a value of about \$42,938. The mines are shallow surface excavations.

Less than 100 tons of copper with a value of about \$40,000 were produced in the Black Hills in the smelting days, but no copper mines of value were developed, and the smelters were forced to ship in copper ores for smelting use from other states.

The clay mined and used in brick-making and other manufacturing processes, was recorded by Mineral Resources only from 1894 to 1920, inclusive, when the production had a value of \$1,320,000. It is not now considered a mine product and so is not included in the table of total mine production which follows.



Figure 10. Mining Bentonite at the F. E. Schundler Bentonite property at Belle Fourche.

Raw clay has been shipped from South Dakota from 1916 to 1934, inclusive, to the extent of 11,246 tons with a value of \$79,453. Most of this clay has been of the variety bentonite. The clay is mined as open cuts and as strippings.

Other minor mine products which have contributed small amounts to South Dakota productions are:—antimony, arsenic, asbestos, graphite, manganese, pumice, and zinc.

17. Summary

The total value of the production of South Dakota mines from 1875 to 1935, inclusive, was more than four hundred five million dollars. Details of this production from 1875 to 1934, are shown in Table Four, where the mine products are arranged in the order in which they have contributed to the total production.

**Table Five: Total Mine Production of South Dakota
From 1875 to 1934, Inclusive**

Product	Years	Amount	Value
Gold	1875-1934	15,902,134 ozs.....	\$338,167,648
Stone	1886-1934	.....	12,186,215
Sand and Gravel.....	1909-1934	32,421,289 tons.....	8,442,450
Portland Cement.....	1891-1934	6,045,304 bbls.....	8,376,749
Silver	1875-1934	8,234,979 ozs.....	6,634,287
Gypsum	1884-1934	343,419 tons.....	1,637,525
Mica	1879-1934	.....	1,401,660
Tungsten	1898-1929	.....	1,331,037
Lime	1896-1934	144,719 tons.....	1,304,437
Coal	1895-1934	477,290 tons.....	1,070,392
Natural Gas	1889-1934	1,083,871 M cu. ft.....	674,323
Lithium Minerals.....	1898-1934	18,709 tons.....	640,145
Lead	1881-1932	.....	441,900
Feldspar	1923-1934	58,924 tons.....	272,019
Pyrites .....	.....	.....	130,000
Tin	1884-1934	358,862 lbs.....	95,410
Clay	1916-1934	11,246 tons.....	79,453
Tantalum Ore.....	1918-1934	80,338 lbs.....	54,187
Bog Iron Ore.....	1893-1925	11,450 tons.....	42,933
Copper	1897-1918	195,691 lbs.....	40,000
Rose Quartz.....	1889-1934	.....	34,729
Beryl	1914-1934	417 tons.....	20,728
Arsenic	1924-1925	89 tons.....	7,167
Andalusite & Silimanite.	1924-1932	66 tons.....	2,470
Pollucite	1928	1 carload.....	2,000
Zinc	1906	12 tons.....	1,440
Miscellaneous (including antimony, asbestos, gra- phite, manganese, pumice, etc.)			50,000
Total Mine Production 1875 to 1934, inclusive.....			\$388,131,309

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PART II

SOUTH DAKOTA MINING LAW

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SOUTH DAKOTA MINING LAW

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In the following analysis of the law affecting the mining industry in South Dakota, the plan attempted is to state the Federal Statute, the State Statute as contained in the South Dakota Revised Code for the year 1919, and some of the general interpretations of these statutes by the Supreme Court of South Dakota. Where there is no marked difference between the Federal and State statutes, the language of only one is quoted. Where brevity demands it, the gist of the statute is given.

It must be understood that this analysis is not complete and that competent legal advice should be obtained by persons engaged in mining development or operation before any important step is taken.

Reservation of Mineral Lands

Federal

In all cases lands valuable for minerals shall be reserved from sale, except as otherwise expressly directed by law. (R. S. 2318; 30 USCA Sec. 21.)

State

All sales, leases and conveyances of lands belonging to the State of South Dakota or to which it may now or hereafter be entitled, including all common school, public buildings and endowment lands shall be subject to and contain a reservation to the State of South Dakota of all deposits of coal, ores, metals and other minerals, asphaltum oil, gas and other like substance in such lands, together with the right to prospect for, mine and remove the same upon rendering compensations to the owner or lessee, for all damages that may be caused by such prospecting or removal; and all money and proceeds derived from the sale or lease of the property and rights reserved by and under the provisions of this section shall inure to the benefit of the funds for which said lands are held by the state or any of its departments. Such reserved deposits shall be disposed of only in the manner hereafter expressly provided by law. (Chap. 308, S. L. South Dakota, 1919).

Persons Entitled to Acquire Lode Claims

Must be citizens of the United States or those who have declared their intentions to become such. (R. S. 2319; 30 USCA Sec. 22).

Lode claim within boundaries of unpatented placer may be located by owner or by another with owner's consent. (McCarthy vs. Speed, 11 S. D. 362, 77 N. W. 790, 50 L. R. A. 184)

Location of Lode Claim

Federal

All valuable mineral deposits in lands belonging to the United States, both surveyed and unsurveyed, shall be free and open to exploration and purchase and the lands in which they are found to occupation and purchase, by citizens of the United States and those who have declared their intention to become such, under regulations prescribed by law, and according to the local customs or rules of miners in the several mining districts, so far as the same are applicable and are not inconsistent with the laws of the United States. (R. S. 2319; 30 USCA Sec. 22)

Dimensions of Lode Claims

Federal

30 USCA Sec. 23; R. S. 2320.

State

Section 8726. *Length of Lode Claim.* The length of any lode claim hereafter located within this state may equal but shall not exceed fifteen hundred feet along the vein or lode.

Section 8727. *Width of Lode Claim.* The width of a lode claim shall be three hundred feet on each side of the center of the vein or lode; provided, that any county may, at any general election, determine upon a width less than three hundred feet but not less than twenty-five feet on each side of the vein or lode.

Jackson vs. Prior Hill Min. Co., 19 S. D. 453, 104. N. W. 207.

Record of Claim

Federal

30 USCA Sec. 28; R. S. 2324.

State

Section 8728. The discoverer of a lode shall within sixty days from the date of the discovery record his claim in the office of the register of deeds of the county in which such lode is situated, by a location certificate, which shall contain:

1. The name of the lode.
2. The name of the locator, or locators.
3. The date of the location.
4. The number of feet in length claimed on each side of the discovery shaft.
5. The number of feet in width claimed on each side of the vein or lode.
6. The general course of the lode as near as may be.

Essentials of title to claim are: Discovery, notice, location, marking boundaries, record. *Marshall vs. Harney Peak Co.*, 1 S. D. 350, 47 N. W. 290.

Certificate Void, When*Federal*

30 USCA Sec. 28; R. S. 2324.

State

Section 8729. Any location certificate of a lode claim which shall not contain the name of the lode, the name of the locator, the date of location, the number of lineal feet claimed on each side of the discovery shaft, the number of feet in width claimed, the general course of the lode, and such description as shall identify the claim with reasonable certainty, shall be void.

When boundaries not marked as prescribed and no minerals of required classes are within the boundaries. *Regan vs. Whitaker*, 14 S. D. 373, 85 N. W. 863.

Manner of Locating*Federal*

30 USCA Sec. 28; R. S. 2324.

State

Section 8730. Before filing such location certificate the discoverer shall locate his claim:

1. By sinking a discovery shaft thereon sufficient to show a well defined mineral vein or lode, and not less than ten feet in depth on the lower side;

2. By posting at the point of discovery, on the surface, a plain sign or notice containing the name of the lode, the name of the locator, or locators, on either side of the discovery, and the number of feet in width claimed on each side of the lode; and

3. By marking the surface boundaries of the claim.

Necessity of actual discovery: *Sands vs. Cruikshank*, 15 S. D. 142, 87 N. W. 589; *McPherson vs. Julius*, 14 S. D. 98, 95 N. W. 428; *Regan vs. Whittaker*, 14 S. D. 373, 70 N. W. 1055.

Absent fraud, decision of land department as to boundaries conclusive. *Golden Reward Min. Co. vs Buxton Min. Co.*, 79 Fed. 868.

Marking Surface Boundaries

Federal

30 USCA Sec. 28; R. S. 2324.

State

Section 8731. Such surface boundaries shall be marked by eight substantial posts, hewed or blazed on the side or sides facing the claim and plainly marked with the name of the lode and the corner, end or side of the claim that they respectively represent, and sunk in the ground: One at each corner and one at the center of each side line, and one at each end of the lode. When it is impracticable, on account of rock or precipitous ground, to sink such posts, they may be placed in a monument of stone.

A stake is not a "post." *United States vs. Sherman*, 288 Fed. 497.

Sufficiency of marking. *Marshall vs. Harney Peak Tin Mining, Milling & Mfg. Company*, 1 S. D. 350, 47 N. W. 290; *McPherson vs. Julius*, 17 S. D. 98, 95 N. W. 428.

Open Cut Instead Shaft

State

Section 8732. Dimensions of Cut of Adit. Any open cut, at least ten foot face, crosscut or tunnel at a depth sufficient to disclose the mineral vein or lode, or an adit of at least ten feet in along the lode from the point where the lode may be in any manner discovered, shall be equivalent to a discovery shaft.

Time Allowed for Sinking Shaft

Federal

30 USCA Sec. 28; R. S. 2324.

State

Section 8733. The discoverer shall have sixty days from the time of uncovering or disclosing a lode to sink a discovery shaft thereon.

What Included in Location

Federal

30 USCA Sec. 26; R. S. 2322.

State

Section 8734. The location or location certificate of any lode claim shall be construed to include all surface ground within the surface lines thereof, and all lodes and ledges throughout their entire depth, the top or apex of which lie inside of such lines extended vertically with such parts of the lodes or ledges as continue by dip beyond the side lines of the claim, but shall not include any portion of such lodes or ledges beyond the end lines of the claim or the end lines continued, whether by dip or otherwise, or beyond the side lines in any other manner than by the dip of the lode.

Rights of Possession

Federal

R. S. 2322; 30 USCA Sec. 26, gives to locators "the exclusive right of possession and enjoyment of all the surface included within the lines of their locations, and of all veins, lodes, and ledges throughout their entire depth, the top or apex of which lies inside of such surface lines extended downward vertically, although such veins, lodes, or ledges may so far depart from a perpendicular in their course downward as to extend outside the vertical side lines of such surface locations."

Limits of Claim

Federal

30 USCA Sec. 26; R. S. 2322.

State

Section 8735. If the top or apex of the lode in its longitud-

inal course extends beyond the exterior lines of the claim at any point on the surface, or as extended vertically downward, such lode may not be followed in its longitudinal course beyond the point where it is intersected by the exterior.

Duggan vs. Davey, 4 Dak. 110, 26 N. W. 887.

Tunnels

Federal

R. S. 2323; 30 USCA Sec. 27, gives to owner of tunnel, right to possession of veins or lodes on line with the same.

Security to Owner of Land

State

Section 8736. When the right to mine is in any case separate from the ownership or right of occupancy to the surface, the owner or rightful occupant of the surface may demand satisfactory security from the miner, and if it be refused, may enjoin such miner from working until such security is given.

Amending Certificate

State

Section 8737. If at any time the locator of any mining claim heretofore or hereafter located, or his assigns, shall apprehend that his original certificate was defective, erroneous, or that the requirements of the law had not been complied with before filing, or shall be desirous of changing his surface boundaries or of taking in any part of an overlapping claim which has been abandoned, and he shall be desirous of securing the benefit of this article, such locator or his assigns may file an additional certificate subject to the provisions of this article; provided, that such relocation does not interfere with the existing rights of others at the time of such relocation; and no such relocation or the record thereof shall preclude the claimant from proving any such title as he may have held under any previous location.

Defective Location. McPherson vs. Julius, 17 S. D. 98, 95 N. W. 428.

Annual Work Required

Federal

Not less than \$100.00 worth of labor shall be performed or improvements made during each year. See R. S. 2324; 30 USCA Sec. 28.

The foregoing requirement has been from time to time suspended by Acts of Congress. May 18, 1933; May 15, 1934; June 13, 1935; April 24, 1936. 30 USCA Sec. 289.

State

Section 8738. *Annual Work Required.* The amount of work to be done or improvements made during each year to hold possession of a mining claim shall be that prescribed by the laws of the United States, to-wit: One hundred dollars annually; provided, that the period within which the work required to be done annually on all unpatented claims so located shall commence on the first day of January succeeding the date of location of such claim.

Burden on adverse claimant to prove forfeiture or intention to abandon. *Axiom Min. Co. vs. White*, 10 S. D. 198, 72 N. W. 462.

Construction of tunnel, work on claim. *Godfrey vs. Faust*, 18 S. D. 567, 101 N. W. 718; s. c., 20 S. D. 203, 105 N. W. 460,

Work prevented, not perfect claim. *Garvey vs. Elder*, 21 S. D. 77, 109 N. W. 508, 130 Am. St. Rep. 704.

Improvements: Assessment work on one claim for a number. *McKirahan vs. Gold King Min. Co.*, 39 S. D. 535, 165 N. W. 542; *Hawgood vs. Emery*, 22 S. D. 573, 119 N. W. 177, 133 Am. St. Rep. 941; *Elder vs. Horseshoe Min. Co.*, 194 U. S. 248, 48 L. Ed 960, 24 Sup. Ct. Rep. 643.

Actual value to mine. *McKirahan vs. Gold King Min. Co.*, 39 S. D. 535, 165 N. W. 542.

By one having contract to purchase. *Godfrey vs. Faust*, 18 S. D. 563, 101 N. W. 718.

Outside limits. *Hawgood vs. Emery*, 22 S. D. 573, 119 N. W. 177, 133 Am. St. Rep. 941.

On one of several claims. *McKirahan vs. Gold King Min. Co. supra*.

Resuming Work After Default

Mining claim locators failure to do assessment work in some years cured by compliance before intervening rights accrue. *Hebert vs. Bond*, 56 S. D. 220, 228 N. W. 185.

Adverse Proceedings Against Defaulting Cotenant

For Federal procedure see 30 USCA Sec. 28; R. S. 2324; *Elder vs. Horseshoe Min. Co.*, 15 S. D. 124, 87 N. W. 586, judgment affirmed 24 S. Ct. 643, 194 U. S. 248, 48 L. Ed. 960.

Total Work Prior to Patent

Federal

A certificate of the United States Supervisors of Surveys must show expenditure of \$500.00 worth of labor or improvements made upon the claim by applicant for patent or grantors. R. S. 2325; 30 USCA Sec. 29.

The procedure for obtaining patent in adverse proceedings and description of claim under Federal statutes are regulated by R. S. 2325-2328; 30 USCA Sec. 30-40.

Relocation

Federal

30 USCA Sec. 26, R. S. 2322.

State

Section 8739. *Abandoned Claim—Relocation.* The relocation of an abandoned lode claim shall be by sinking a new discovery shaft and fixing new boundaries in the same manner as if it were the location of a new claim, or the relocater may sink the original shaft, cut or adit to a sufficient depth to comply with the requirement of an original location, and erect new or adopt the old boundaries, renewing the posts if removed or destroyed. In either case a new location stake shall be erected. In any case, whether the whole or part or an abandoned claim is taken, the location is located as abandoned property.

Co-owner does not abandon land by relocation. *Hulst vs. Doerstler*, 11 S. D. 14, 75 N. W. 270.

Cotenant relocating, trustee. *McCarthy vs. Speed*, 11 S. D. 362, 77 N. W. 590, 50 L. R. A. 184.

Locator of excess fraction, not trustee. *Regan vs. McKibben*, 11 S. D. 270, 76 N. W. 943.

Employee leaving work under threat of arrest not abandonment such as to permit relocation. *Garvey vs. Elder*, 21 S. D. 77, 109 N. W. 508.

Relocator must show abandonment. *Dibble vs. Castle Chief Gold Mining Co.*, 9 S. D. 618, 70 N. W. 1055.

One obtaining homestead patent by false and fraudulent representations, trustee for prior locator. *Hebert vs. Bond*, 56 S. D. 220, 228 N. W. 185.

Certificate Limited to Single Location

State

Section 8740. No location certificate shall claim more than one location, whether the location be made by one or several locators; and if it purports to claim more than one location it shall be absolutely void, except as to the first location therein described, and if they are described together, or so that it cannot be told which location is first described, the certificate shall be void as to all.

Recording Fee

State

Section 8741. The register of deeds shall be entitled to receive the sum of one dollar for each location certificate recorded and certified by him, and shall furnish the locator or locators with a certified copy of such certificate when demanded, for which he shall be entitled to receive fifty cents.

Claims Under Location May Be Transferred Before Patent

Claim is alienable. *Sussenbach vs. First National Bank*, 5 Dak. 477, 41 N. W. 662.

Alien may convey as against everybody but the United States. *Gorman Mining Co. vs. Alexander*, 3 S. D. 3, 51 N. W. 346.

Survey in Case of Dispute

State

Section 8742 provides for underground survey in actions wherein the title or right of possession to mining claim is in dispute.

Power of Court of Equity to order survey not abridged. *Dugan vs. Davey*, 4 Dak. 110, 26 N. W. 887.

Right of Ingress

State

Section 8744. The proprietor, owner or owners of mining claims, whether patented under the laws of the United States or held under the local laws and customs of the state, shall have a right of way for ingress for necessary purposes over and across the land or mining claim of others, patented or otherwise, as provided in this article.

Right of Way — Road or Ditch

State

Section 8745. Whenever any such mine or mining claim shall be so situated that it cannot be conveniently worked without a road thereto, or a ditch or a cut to convey the water therefrom, or without a flume to carry water and tailings therefrom, or without a shaft or tunnel thereto, which road, ditch, cut or tunnel shall necessarily pass over, under, through or across any lands or mining claims owned or occupied by others, either under a patent from the United States or otherwise, such owner or owners shall be entitled to a right of way for such road, ditch, flume, shaft or tunnel over, under, through and across such other lands or mining claims upon compliance with the provisions of this article.

PLACER CLAIMS

Conforming Entry to Legal Subdivisions

Claims usually called "placers", including all forms of deposit, excepting veins of quartz, or other rock in place, shall be subject to entry and patent, under like circumstances and conditions, and upon similar proceedings, as are provided for vein or

lode claims; but where the lands have been previously surveyed by the United States, the entry in its exterior limits shall conform to the legal subdivisions of the public lands. And where placer claim are upon surveyed land, and conform to legal subdivisions, no further survey or plat shall be required, and all placer-mining claims located after the 10th day of May, 1872, shall conform as near as practicable with the United States system of public-land surveys, and the rectangular subdivisions of such surveys, and no such location shall include more than twenty acres for each individual claimant; but where placer claims cannot be conformed to legal subdivisions, survey and plat shall be made as on unsurveyed lands; and where by segregation of mineral land in any legal subdivision a quantity of agricultural land less than forty acres remains, such fractional portion of agricultural land may be entered by any party qualified by law, for homestead purposes. 30 USCA Sec. 35; R. S. 2329 and 2331.

Subdivision into Ten Acre Tracts

Subdivision into Ten Acre Tracts

Legal subdivisions of forty acres may be subdivided into ten-acre tracts; and two or more persons, or associations of persons, having contiguous claims of any size, although such claims may be less than ten acres each, may make joint entry thereof; but no location of a placer claim, made after the ninth day of July, eighteen hundred and seventy, shall exceed one hundred and sixty acres for any one person or association of persons, which location shall conform to the United States surveys; and nothing in this section contained shall defeat or impair any bona fide preemption or homestead claim upon agricultural lands, or authorize the sale of the improvements of any bona fide settler to any purchaser. 30 USCA Sec. 36; R.S. 2330.

Proceedings for Patent

Where the same person, association, or corporation is in possession of a placer claim, and also a vein or lode included within the boundaries thereof, application shall be made for a patent for the placer claim, with the statement that it includes such vein or lode, and in such case a patent shall issue for the

placer claim, subject to the provisions of this chapter, including such vein or lode, upon the payment of five dollars per acre for such vein or lode claim and twenty-five feet of surface on each side thereof. The remainder of the placer claim or any placer claim not embracing any vein or lode claim shall be paid for at the rate of two dollars and fifty cents per acre, together with all costs of proceedings; and where a vein or lode, such as is described in section twenty-three of this title, is known to exist within the boundaries of a placer claim, an application for a patent for such placer claim which does not include an application for the vein or lode claim shall be construed as a conclusive declaration that the claimant of the placer claim has no right of possession of the vein or lode claim; but where the existence of a vein or lode in a placer claim is not known, a patent for the placer claim shall convey all valuable mineral and other deposits within the boundaries thereof. 30 USCA Sec. 37; R. S. 2333.

Liens Prior to Patent

R. S. U. S. 2332 provides that nothing contained in Chapter 2 of Title 30, USCA "shall be deemed to impair any lien which may have attached in any way whatever to any mining claim or property thereto attached prior to the issuance of a patent." 30 USCA Sec. 38.

Miners' Liens

Sections 1631—1642, inclusive, S. D. Revised Code 1919, define who are entitled to miners' liens, to whom the account is to be presented, the method of filing a lien statement and the foreclosure of a miner's lien. These statutes cannot be satisfactorily summarized, as each step is important. Section 1635, as amended by Chapter 261 of the Session Laws of 1919 is as follows:

"LIEN STATEMENT FILED. Any person entitled to a lien under this article shall make a statement in writing, and attach thereto an account of the items of labor, machinery, power, light, compressed air or materials furnished, as the case may be, as provided in the fourth preceding section, and after making oath thereto shall within sixty days from the time of the completion of such labor, or furnishing the last item of machinery,

power, light, air or materials, as aforesaid, file the same in the office of the clerk of courts of the county in which the mining property may be situated, or of the county to which such county is attached for judicial purposes. Such statement shall contain a description of the property to be charged with said lien sufficient to identify it, and the postoffice address of the person filing the statement, which statement and account when filed shall be docketed by the clerk of courts in a separate book, and to be marked "Miner's Lien Record," wherein he shall record the name of the person filing said lien, and his postoffice address, the name of the person owning the property against which said lien is filed, together with a description of the property upon which said lien is filed, as the same is contained in the statement, the date of filing, and the total amount due on said account, and thereupon the same shall, from the time of the completion of the work or furnishing of the last item of machinery, power, light, air or materials, and for one year thereafter, operate as a lien for the amount of said account and interest, upon the property described in said statement. Provided, that all liens, claims for labor performed, or light, power, air or materials furnished, as provided in the fourth preceding section, shall be concurrent liens upon the property charged and shall be paid pro rata out of the proceeds arising from the sale thereof, if the same shall be sold, or upon settlement without sale."

Miners' lien law repealed by enactment of mechanics' lien law. *Cessna vs. Otho Development and Power Company*, 35 S. D. 557, 153, N.W. 380. Miners' lien law reenacted by adoption 1919 code.

Materials must be used in construction of some specific building, erection or improvement. *Sutton vs. Consolidated Apex Mining Company*, 14 S. D. 33, 84 N.W. 211; 51 S. D. 410, 89 N.W. 1020.

Claim must be founded on contract. *Union Trust Company vs. Branch Mint Operating Company*, 28 S.D. 549, 134 N.W. 65.

General manager may be entitled to lien. *Hahn vs. Anaconda Gold Mining Company*, 26 S. D. 218, 128 N.W. 128.

Mine Inspection

Sections 8705—8718, R. C. 1919 provide for the appointment of a mine inspector and prescribes the duties of his office. There have been no monies appropriated for the payment of his salary for several sessions of the State Legislature and, as a result, the office has been vacant.

Safety Regulations

Sections 8719—8725 provide safety regulations and makes it the duty of the State Mine Inspector to enforce them. Every mine operator is referred to those sections for information as to the statutory provisions for the safety of employees engaged in mining. Only that section containing the code of bell signals is given here.

Mine Signals

State

At all mines where hoisting apparatus is operated the following code of bell signals shall hereafter be adopted and used:

One bell, hoist; one bell, stop (if in motion.)

Two bells, lower men; three bells, hoist men.

Four bells, blasting signal. Engineer must answer by raising bucket or cage a few feet and letting it back slowly; then one bell, hoist men away from blast.

Five bells, steam on; six bells, steam off.

Seven bells, air on; eight bells, air off.

Three-two-two bells, send down tools.

Nine bells, danger signal (fire, accident or other danger). Then ring number of station where danger exists. No person shall ring any signal bell except the station tender, except in case of danger, or when the main shaft is being sunk.

Engineers must slow up when passing stations when men are on the cage or bucket.

Station Bells							
Bells.	Pause.	Bells.	No. Station	Bells.	Pause.	Bells.	No. Station
2	"	1	1	4	"	1	11
2	"	2	2	4	"	2	12
2	"	3	3	4	"	3	13
2	"	4	4	4	"	4	14
2	"	5	5	4	"	5	15
3	"	1	6	5	"	1	16
3	"	2	7	5	"	2	17
3	"	3	8	5	"	3	18
3	"	4	9	5	"	4	19
3	"	5	10	5	"	5	20 .

If cage is wanted ring station signal. Station tender will respond in person.

If station is full of ore and station tender is wanted, ring station signal.

One copy of this code shall be posed on the gallows frame and one before the engineer.

Any person who shall violate the provisions of this section shall be deemed guilty of a misdemeanor and upon conviction thereof shall be punished by a fine of not less than one hundred nor more than three hundred dollars, or by imprisonment in the county jail not exceeding three months for each offense.

Special Taxes on Mines

Ore Tax and Exemptions

Chapter 203, Session Laws of 1935, being House Bill No. 4, imposes a tax on the extraction of ore. The act is too long to be included in this analysis. It imposes upon everyone engaged in the business of mining, severing, or extracting from the lands and the natural resources of this state, or processing the same, any gold, silver, lead, tin, or other mineral products or combinations thereof, a tax equal to four per cent of the value of the article produced. It exempts from the tax so imposed the value of all production accruing from the first fifty thousand tons of ore mined during any one calendar year to anyone so engaged.

Chapter 205 of the Session Laws of 1935 exempts from the

provisions of the property relief act all persons who pay the ore tax under the provisions of Chapter 203, Session Laws of 1935.

Blue Sky Law

Exemption of Mining Securities

By Chapter 237, Session Laws of 1929, a further exemption from the operation of the Blue Sky Law was given to mining corporations by Subdivision 11 of Section 3, which is as follows:

"Any securities issued by a corporation organized under the laws of this state or authorized to do business in this state for the purpose of drilling for petroleum oil, gas, mining, metallurgical plants or other development of the mineral resources of this state.

Provided that the securities listed in this subdivision shall be exempted from the provisions of this Act only when such exemption is claimed in the following manner:

That the Securities Commission shall, upon application of reputable corporations organized under the laws of the state, register the securities of such corporations enumerated in this subdivision of this section upon such corporation filing with the said Securities Commission its agreement in writing, properly executed, conditioned that the said corporation, its officers or agents, will file, on the first day of January, April, July and October a full and complete statement showing the names of purchasers of securities of the said corporation, the amount of such purchases, and showing in detail the expenditures of all moneys received during the previous quarter year including unexpended balances, and further conditioned that all moneys received from the sale of any such securities, excepting a reasonable percentage, to be stated in such agreement, to be used for promotion expense, will be expended in the actual work of developing said project. After the issuance of certificate of registration, and immediately upon the failure of the said corporation to comply with any of the conditions of the said agreement, the executive officer of the Securities Commission shall certify such failure to the Attorney General of the State, whose duty it shall be to give immediate notice to the representatives of the said corporation to appear and show cause why such registration should not be revoked. Should

the representatives of the corporation fail to appear, as required by such notice, or, after due hearing and investigation by the said Attorney General, it should appear that said agreement has not been kept, upon recommendation to that effect by the said Attorney General the said Securities Commission shall revoke the said registration and no further sales of the securities of the said corporation shall be made in this state.

The Attorney General of this state shall have full authority to adjust and determine any questions that may arise over the "interpretations of the provisions of this Section as between the applicant for registration and the Securities Commission. Either the corporation or Securities Commission shall have the right of appeal to the circuit court from the decision of the Attorney General."

This exemption has not been generally claimed by mining corporations for the reason that mining corporations desiring to sell securities find it advantageous to comply with the requirements of the Blue Sky Law and to register their securities by application as required by Chapter 206 of the Session Laws of South Dakota for the year 1927, as amended by Chapter 180 of the Session Laws of 1933.

Conclusion

The foregoing analysis of the laws pertaining to mining is necessarily incomplete. It is not intended to make every mining man his own lawyer, any more than every mining man may safely be his own mining engineer and his own assayer.

Chapter 2 of Title 30 of the United States Code Annotated dealing with mineral lands and regulations in general which has been reviewed in the making of the foregoing analysis occupies over three hundred pages in that Code. The Supplement for the year 1936 alone is many times as long as this entire analysis.

While not intended as a text-book on mining law, it is hoped that the foregoing analysis may prove helpful to those interested in revealing and developing the mineral resources of our state.

PART III

MINING DIRECTORY OF SOUTH DAKOTA

Prepared under the auspices of
The South Dakota State Planning Board

By
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EXPLANATORY PREFACE

There has always been a large demand for information concerning the mining properties of South Dakota. Since the establishment of the Rapid City Branch Office of the South Dakota State Planning Board, many of these inquiries, received from persons both in the state and out of the state, have been directed to this office. The nature of the information desired is such that the publication of a Directory of Mining Properties seems to be justified.

Since there was no South Dakota mining directory in existence to serve as a model, it was necessary to start with a list of properties made up from inquiries directed to such persons as were familiar with the mining properties in their respective districts, and from information obtained from various publications in the library of the South Dakota State School of Mines. After this list had been completed, form letters asking for the information necessary to give a short description of each property, were sent either to the owner or to some person familiar with the property. In many cases it was impossible to contact persons who were familiar enough with a property to give this information. If such were the case, a description taken from a former publication or publications was the sole source of information. Upon completing the manuscript for each property, a copy was sent to the owner or other interested party to be checked. Those manuscripts which were not returned with corrections were assumed to be correct.

It is realized that this work has probably not resulted in a complete list of the mining properties of South Dakota, although no property has been omitted intentionally. It is also realized that errors probably occur in many of the descriptions. It is hoped, however, that these omissions and mistakes may be corrected each year and the whole directory revised and brought up to date. With the continued cooperation of mine operators, owners and interested parties, succeeding editions may be made more accurate and complete.

MINING DIRECTORY OF SOUTH DAKOTA**Beadle County**

ISABELL SAND & GRAVEL CO.: *Location:* Huron. *Ownership:* A. R. Isabell, Owner and superintendent, Huron, S. D. *Valuable Material:* Sand-Gravel. *Annual Production:* 20,000 tons. *Mine Plant:* Scrapers, Conveyors. *Mill Plant:* Screens, Washer.

Butte County

AMERICAN COLLOID COMPANY: *Location:* Near Belle Fourche. *Ownership:* American Colloid Co., 363 Superior St., Chicago, Ill. *Incorporated:* State of South Dakota, July, 1924. *Capital Stock:* 150,000 shares having a par value of \$1.00. *Shares Issued:* 124,000. *Type of Deposit:* Flat bed, outcropping. *Valuable Mineral:* Bentonite. *Treatment Plant:* Drying and grinding plant. *Development:* Strip mining. *Remarks:* Operating, employing 20 men.

BELLE FOURCHE BENTONITE PRODUCTS CO., INC.: *Location:* Unorganized mining district, 5 to 15 miles from Belle Fourche. *Ownership:* W. I. Smith, Belle Fourche, S. Dak. *Property:* 24 unpatented claims, approximately 2,960 acres. *Type of Deposit:* Flat bed overlain by shale, 6" to 20' deep and with underlying bed of greenhorn shale. *Valuable Mineral:* Bentonite. *Development:* Test pits. *Remarks:* Assessment work only.

BLACK HILLS CLAY PRODUCTS CO.: *Location:* Plant at Belle Fourche; clay deposit 3 miles south of Belle Fourche on Highway 85. *General Manager:* W. F. Thomas, Belle Fourche, S. Dak. *Property:* Consists of 40 acres, patented. *Type of Deposit:* Flat-lying clay. *Valuable Material:* Brick, building tile, and drain tile. *Remarks:* Operating the plant at Belle Fourche and producing the above-named materials.

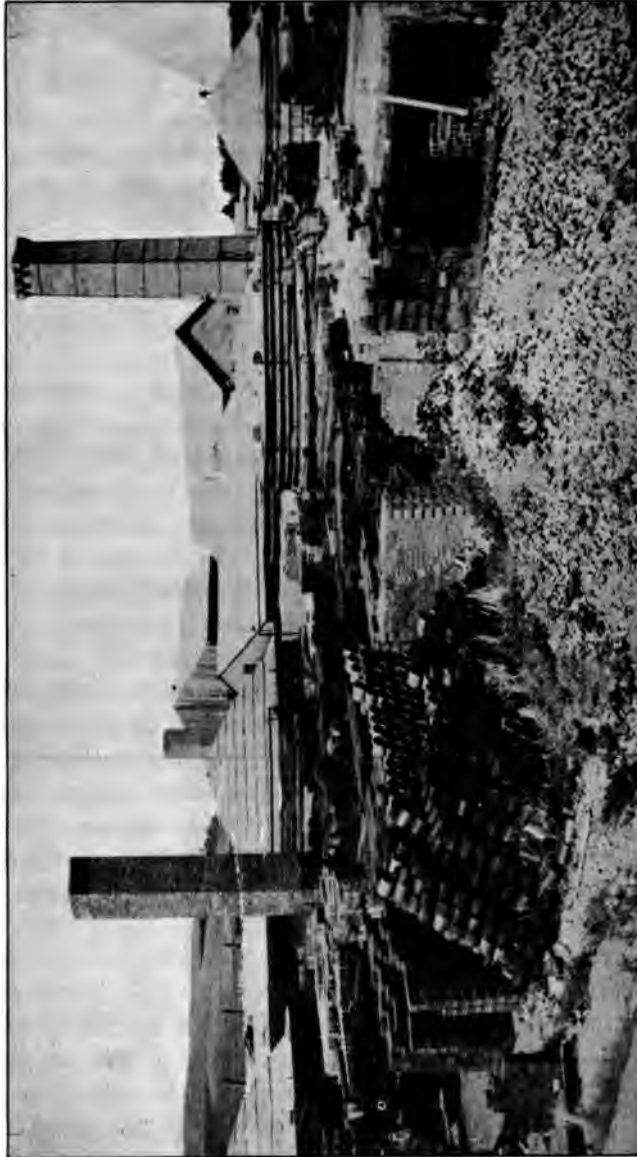


Figure 11. Black Hills Clay Products Company Plant at Belle Fourche



Figure 12. The F. E. Schundler Bentonite Plant at Belle Fourche.

F. E. SCHUNDLER BENTONITE: *Location:* Plant at Belle Fourche, S. Dak. *Local Representative:* Harold Eyrick, Belle Fourche, S. Dak.

Codington County

ZELLER'S CONCRETE MATERIALS CO.: *Location:* Watertown. *Ownership:* Zeller's Concrete Materials Co. *President and Manager:* William Zeller, Watertown, S. Dak. *Valuable Material:* Sand-Gravel. *Production:* 75,000 tons. *Mine Plant:* Pumps, screens. *Mill Plant:* Washer and crusher.

Corson County

ANDERSON COAL PROPERTY: *Location:* Near Gopher. *Ownership:* Andrew Anderson, Gopher, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal.

HUNT COAL PROPERTY: *Location:* Near McIntosh. *Ownership:* Frank Hunt, McIntosh, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal. *Remarks:* Recent letter returned unclaimed.



Figure 13. The Kennedy Coal Mine near Gopher

KENNEDY COAL PROPERTY: *Location:* Near Gopher. *Ownership:* W. D. Kennedy, Gopher, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Material:* Lignite coal.

LANGERMAN COAL PROPERTY: *Location:* Near McIntosh. *Ownership:* Carl Langerman, McIntosh, S. Dak. (Same as Britsch and Vilhauer). *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite Coal. *Remarks:* Abandoned 1930.

Custer County

ABINGDON SANITARY MFG. CO.: Operates the White Elephant Mine, which see.

APEX LODGE: *Location:* 5 miles west of Custer in an unorganized mining district. *Ownership:* Mr. F. J. Fenwick, Custer, S. Dak., and L. C. Green, Hill City, S. Dak. *Property:* 1 unpatented claim approximately 20 acres. *Type of Deposit:* Pegmatite. *Valuable Minerals:* Chiefly Feldspar, small amount of Beryl, Mica and some Columbite. *Develop-*

ment: Small open cuts. *Remarks*: Assessment work only.

BEECHER LODGE: Formerly Bond Claim. *Location*: In an unorganized mining district, 5 miles northeast of Pringle. *Ownership*: L. C. Greene, and Louis Collingwood, Pringle, S. Dak. *Property*: 1 patented claim, 20 acres. *Type of Deposit*: Pegmatite. *Valuable Minerals*: Beryl, Amblygonite, Columbite, Mica, Tin, altered Spodumene and Feldspar. *Development*: 150 feet of tunneling; a number of open cuts and several shallow shafts. *Production*: 1907-1935, Amblygonite, 800 tons, \$32,000; 1927-1935, Beryl, 60 tons, \$1,800; Columbite, 24 tons, \$28,800; Mica 150 tons, \$1,500. *Remarks*: Operating, employing 8 men.

BERYL MICA LODGE: Near Pringle; See Dakota Feldspar Co.

BIG TOM AND BIG TOM NO. 1: *Location*: 6 miles west of Custer. *Ownership*: Francis Michaud, Custer, S. Dak., Palmer Hibbard, Pringle, S. Dak., Monte Heumphreus, Custer S. Dak. *Type of Deposit*: Pegmatite. *Valuable Minerals*: Soda and Potash-Feldspar, Beryl, and Amblygonite. *Development*: By small open cuts. *Remarks*: A prospect.

BLACK HILLS LIME CO.: *Location*: 2 miles southwest of Pringle. *Ownership*: Black Hills Lime Co. *Officers*: J. A. Kirk, President; T. P. Kirk, Vice-President; S. A. Kirk, Secretary and Manager. *Incorporated*: South Dakota, 1899. *Property*: 620 acres patented and 160 acres unpatented. *Type of Deposit*: Flat bed overlain by a little overburden. *Valuable Material*: Pahasapa limestone. *Development*: Open cut stepped-face quarry. *Mine Plant*: Rock drills, quarry cars, compressor, smaller equipment. *Treatment Plant*: Two 8-ton kilns, 16 tons per hour capacity. *Production*: 1899-1935, approximately 17,000 tons of lime. *Remarks*: Operating and employing 9 men.

BOND CLAIM: See Beecher Lodge.

CLIMAX MICA MINE: *Location*: 2 miles east of Custer. *Type of Deposit*: A pegmatite. *Valuable Minerals*: Mica and Beryl. *Remarks*: Idle at present time. *References*: (4) (19).

COOK'S MICA MINE: *Location:* 4 miles southwest of Custer. A pegmatite. *Reference:* (5)

C. PALMER PLACER: *Location:* $\frac{1}{2}$ mile west of Custer. *Equipment:* A drag-line excavator and sluices. *Remarks:* Largest gold producer in Custer County, 1934. Operating during summer of 1935. *References:* (20) (21).

CROWN MICA MINE: Formerly the McMackin. *Location:* $2\frac{1}{2}$ miles northwest of Custer. *Ownership:* Fred Heidepreim and John Wells, Custer, S. Dak. *Property:* 1 unpatented claim. *Type of Deposit:* Pegmatite. *Valuable Minerals:* Amblygonite, Mica and Columbite. *Development:* By open cuts, 100' shaft, drifts and crosscuts. *Remarks:* Intermittent operation at present time. *Reference:* (4).

CUSTER CLAIM: *Location:* Near Custer. *Type of Deposit:* Pegmatite. *Valuable Mineral:* Beryl. *Reference:* (19).

DAKOTA FELDSPAR CO.: Formerly the Beryl Mica Lode. *Location:* In an unorganized mining district, 5 miles south of Pringle. *Local Representative:* A. T. Roos, Deadwood, S. Dak. *Officers:* Chas. S. Reed, Rapid City, S. Dak., President; Florence Patterson, Rapid City, S. Dak., Secretary. *Incorporated:* South Dakota, 1925. *Capital Stock:* 500,000 shares. *Par Value:* 24c per share, 187,000 shares issued. *Property:* 2 unpatented claims, approximately 40 acres. *Type of Deposit:* Pegmatite. *Valuable Minerals:* Feldspar, Beryl, Mica, Columbite. *Development:* Open cut system employed, also 260' of tunneling. *Remarks:* Leased by Louis Collingwood; employing 6 men.

DICKEY PLACER: *Location:* On French Creek, near Custer. *Equipment:* Dragline excavator and sluices. *Remarks:* Operated during summer of 1935. *Reference:* (21).

DOROTHY VAN PLACER: *Location:* Near Custer. *Remarks:* A dragline excavator operated for a period of one month during 1934 and recovered 13.09 ozs. of gold. Also worked during 1935. *References:* (20) (21).

DOWNING'S CLAIM: See Kirka.

DUSTY PLACER CLAIM: *Location:* In an unorganized mining district $2\frac{1}{2}$ miles southeast of Custer. *Ownership:* Miss Carrol Case, 7641 East Lake Terrace, Chicago, Ill. *Property:* 1 unpatented claim approximately 20 acres. *Type of Deposit:* Gulch Placer. *Ore:* Gold. *Development:* Several open cuts. *Remarks:* Assessment work only at present time.

EUREKA MICA MINE: *Location:* Near Custer. *Type of Deposit:* Pegmatite, worked chiefly for Mica. *Reference:* (13).

FIRESTONE MICA MINE: *Location:* $4\frac{1}{2}$ miles southwest of Custer. *Reference:* (4).

GALESBURG MICA MINE: *Location:* $4\frac{1}{2}$ miles southeast of Custer. *Reference:* (4).

GEM MICA CLAIM: *Location:* Near Custer. *Type of Deposit:* Pegmatite. *Valuable Minerals:* Beryl and Mica. *Reference:* (19).

GERGERSON'S RANCH: Clay deposit leased by Rushmore Clay Products Co., Rapid City, S. Dak. *Location:* In unorganized mining district, 7 miles southwest of Fairburn. *Ownership:* Mr. Hans Gergerson, Fairburn, S. Dak. *Property:* 1 patented claim, approximately 40 acres. *Type of Deposit:* Yellowish, gritty clay, nodular structure, flat-lying deposit, 8' in depth. *Valuable Material:* Fuller's Earth. *Development:* Open pit method employed. *Remarks:* Idle at present

GOLDEN CROWN: Formerly the LeRoy Mine. *Location:* In an unorganized mining district, $3\frac{1}{2}$ miles northwest of Custer. *Ownership:* Mr. Fred Brown and A. J. Muller, Custer, S. Dak. *Property:* 1 unpatented claim, approximately 20 acres. *Type of Deposit:* Fissure vein. *Ore:* Gold and some Silver. *Development:* One 85' shaft and 125' of drifting and crosscutting. *Mine Plant:* One $\frac{1}{2}$ -in. air pump, one 2" force pump, one 3" high speed centrifugal pump. *Mill:* 5-stamp mill and amalgamating plates. *Power:* One Dodge 35 HP motor and one Red Seal Continental 40 HP motor. *Remarks:* Recently examined for RFC loan.

GOLD KEY: *Ore:* Gold. *Reference:* (12).

GOLD NUGGET PLACER: *Location:* 9 miles northwest of Custer in an unorganized mining district. *Ownership:* Mr. Tom Petty and F. J. Fenwick, Custer, S. Dak. *Property:* 1 unpatented claim of approximately 20 acres area. *Type of Deposit:* Creek placer. *Ore:* Gold. *Development:* By open pits. *Remarks:* Assessment work only

GOLD RESERVE: Formerly the Saginaw Mine. *Location:* In an unorganized mining district, 8½ miles west of Custer. *Ownership:* Mr. S. R. Herber, Custer, S. Dak. *Property:* 1 unpatented claim and 4 patented claims aggregating approximately 116 acres. *Type of Deposit:* Quartz lenses in pre-Cambrian slate and schist. *Ore:* Gold and some Silver. *Development:* Three shafts, 60', 384' and 50' in depth; 250' of drifting and crosscutting. *Remarks:* Idle since 1909. Recently examined for RFC loan.

GRAND HILLS MINING COMPANY: *Location:* 2 miles west of Custer. *Local Representative:* Roy Gish, Custer, S. Dak. *Type of Deposit:* Creek placer. *Ore:* Gold. *Remarks:* Operated dragline during summer of 1935.

GRANT LODGE: See Wild Rose Mine.

GREAT NORTHERN MICA MINE: Formerly the Old Mike Mine. *Location:* 3½ miles northwest of Custer. *Type of Deposit:* Pegmatite. *Valuable Mineral:* Beryl and Mica. *Remarks:* Produced mica in 1935. *References:* (4) (19).

HARBACH PLACER: *Location:* 1 mile east of Custer, in an unorganized mining district. *Ownership:* Leo G. Harbach, Custer, S. Dak. *Property:* 220 acres, patented. *Type of Deposit:* Creek placer. *Ore:* Gold. *Method of Mining:* By stripping and back-filling. *Equipment:* ¾ cu. yd. Sargent dragline, revolving screen and sluice; 30 cu. yds. per day capacity. *Remarks:* Operated during summer of 1935; idle at the present time.

HARD SCRABBLE: Formerly the North Star Mine. *Location:* In an unorganized mining district, 9 miles northwest of

Custer. *Ownership*: Mr. Frank A. Miller, Custer, S. Dak. *Property*: 3 unpatented claims, approximately 56 acres. *Type of Deposit*: Small quartz shoots in pre-Cambrian slate and schist. *Ore*: Gold and some Silver. *Development*: Several shallow shafts and one which is 300' in depth; 1,200' of drifting and crosscutting. *Remarks*: Except for assessment work this property has been idle since 1902.

H. W. FOWLER PROPERTY: See Tin Mountain.

HITCHCOCK MICA MINE: *Location*: Near Custer. *Type of Deposit*: Pegmatite. *Valuable Minerals*: Mica and Beryl. *Reference*: (19).

JOHN ERPELDING QUARRY: *Location*: Southwest of Pringle near Loring Siding. *Ownership*: John Erpelding, Pringle, S. Dak. *Type of Deposit*: Flat bed with little overburden. *Valuable Material*: Pahasapa limestone. *Development*: Open cut stepped-face quarry. *Treatment Plant*: One kiln now practically dismantled. *Remarks*: Intermittent operation.

KEYSTONE MICA CLAIM: *Location*: Near Custer. *Type of Deposit*: Pegmatite. *Reference*: (13).

KIRKA CLAIM: Formerly Downing's Claim. *Location*: 7 miles southwest of Hill City in Custer County. *Ownership*: Floyd Hemen and J. E. Kurka, Custer, S. Dak. *Property*: 1 unpatented claim approximately 20 acres. *Type of Deposit*: Wolframite occurring with pyrite, muscovite and biotite in a quartz vein, the maximum width of which is about 14" *Ore*: Tungsten. *Development*: Consists of prospect cuts for 50' along the vein and at a maximum depth of 15' below the surface. *Remarks*: Prospected in 1917 and 1918, assessment work only at the present time. *Production*: Said to have been some production from here in 1918. *Reference*: (16).

LAST CHANCE: *Location*: Near Custer. *Type of Deposit*: Pegmatite. *Valuable Mineral*: Mica. *Reference*: (13).

LeROY MINE: See Golden Crown.

LOST BONANZA: See Mica King.

LOUISE TIN CLAIM: *Location:* 7 miles northwest of Custer, in an unorganized mining district. *Ownership:* C. A. Hunter and C. A. Trautman, Custer, S. Dak. *Property:* 1 unpatented claim, approximately 20 acres. *Development:* Several small open cuts. *Type of Deposit:* Pegmatite. *Ore:* Tin. *Remarks:* This is a prospect only. *References:* (3) (5).

LUCKY SPAR MINE: *Location:* 2 miles south of Custer in an unorganized mining district. *Ownership:* Fred Heidepreim and Floyd Hemen, Custer, S. Dak. *Property:* 1 unpatented claim, approximately 20 acres. *Type of Deposit:* Pegmatite. *Valuable Minerals:* Feldspar, Beryl, and Mica. *Remarks:* Assessment work only.

LUCKY TWIST: *Location:* 2 miles south of Custer in an unorganized mining district, 4 miles northeast of Pringle. *Ownership:* Mr. Kenneth Sutherland and Bros. *Property:* 1 unpatented claim, approximately 20 acres. *Type of Deposit:* Pegmatite. *Valuable Minerals:* Feldspar, Scrap Mica, and Rose Quartz. *Development:* Open cuts. *Production:* 190 tons of Feldspar. *Remarks:* Operated and employed 2 men during summer of 1935.

LUCKY VALLEY PLACER: *Location:* In an unorganized mining district, 2½ miles east of Custer. *Ownership:* Mr. Emery E. Howard, Custer, S. Dak. *Property:* 2 unpatented claims, approximately 36 acres. *Type of Deposit:* High bar and residual placer. *Ore:* Gold. *Development:* Developed by trenching and test pits. *Remarks:* Operating, employing two men. Recently examined for RFC loan.

MAHNKE PEGMATITE: *Location:* In unorganized mining district, 6 miles northwest of Custer. *Ownership:* Mr. John Wilhelm, Custer, S. Dak. *Property:* A five-acre fraction of a patented claim. *Type of Deposit:* Pegmatite. *Valuable Minerals:* Feldspar, Beryl and Mica. *Development:* A 25' shaft and open cuts. *Production:* Dec., 1934 - April, 1935, 688 tons. *Remarks:* Under lease to Harold Eyrick and

associates. Operation of the property recently resumed by leasers.

MAY GROUP: *Location:* 10 miles southwest of Custer in an unorganized mining district. *Ownership:* Francis Michaud, Custer, S. Dak., Palmer Hibbard, Pringle, S. Dak., Monte Heumphreus, Custer, S. Dak., Mary and Ford Heumphreus, Custer, S. Dak., Dr. Youngblood, Cincinnati, O. *Property:* 7 unpatented claims, approximately 130 acres. *Type of Deposit:* Small quartz veins in fractured slate and schist. *Ore:* Gold and some Silver. *Development:* Inclined shaft 100' in depth; two shafts 60' and 70' in depth. *Mine Plant:* Compressor, Sullivan Jack Hammer, and a 4' x 6' sinking hoist. *Power:* 37 HP Red Seal Continental Motor. *Remarks:* 3 men working at present, sinking shaft.

MAYWOOD CLAIM: *Location:* Near Custer. *Ownership:* Maywood Chemical Works. *Type of Deposit:* Pegmatite. *Valuable Mineral:* Beryl. *Reference:* (19).

McMACKIN: See Crown Mica Mine.

MICA KING: Formerly the Lost Bonanza. 1½ miles north of Custer. *Type of Deposit:* Pegmatite. *Reference:* (5).

MICHAUD CLAIM: *Location:* 8 miles southwest of Custer. *Type of Deposit:* Pegmatite. *Valuable Mineral:* Beryl. *Reference:* (19).

MILE HIGH & SALLY: *Location:* 5 miles northwest of Custer in an unorganized mining district. *Ownership:* Messrs. August Doll, Chas. A. Clark, Ervin A. Hudson, Custer, S. Dak. *Property:* 8 unpatented claims, approximately 160 acres. *Type of Deposit:* Quartz vein in pre-Cambrian slates and schists. *Ore:* Gold and some Silver. *Development:* Developed by tunneling and open cuts. *Remarks:* Assessment work only.

MILLARD MICA MINE: *Location:* Near Custer. *Type of Deposit:* Pegmatite. *Reference:* (13).

MONARCH MICA MINE: *Location:* Near Custer. *Type of Deposit:* Pegmatite. *Reference:* (11).

MOUNTAIN BERYL: *Location:* In an unorganized mining district, 2½ miles northwest of Pringle. *Ownership:* S. T. Gamber, Pringle, S. Dak. *Property:* 1 unpatented claim, approximately 20 acres. *Type of Deposit:* Pegmatite. *Valuable Minerals:* Feldspar, Beryl and some Columbite. *Development:* 649 sq. ft. of open cuts. *Production:* 1929-1935, 1½ tons of Beryl, 10 tons of specimens. *Remarks:* Idle at the present time.

MOUNTAIN ROSE: *Location:* In an unorganized district, 1 mile north of Pringle. *Ownership:* Mr. L. D. Pitts, Pringle, S. Dak. *Property:* 1 unpatented claim, approximately 20 acres. *Type of Deposit:* Pegmatite. *Valuable Minerals:* Feldspar, Mica and Beryl. *Development:* Open Cuts. *Production:* 1931, 2 tons of Beryl, 15 tons of Mica; 1934, 700 lbs. of Beryl, 50 tons of Feldspar, 1 ton of Mica. *Remarks:* Assessment work only at the present time.

NELLY MICA MINE: *Location:* Near Custer. *Type of Deposit:* Pegmatite. *Valuable Mineral:* Mica. *Reference:* (13).

NEWARK MINE: *Location:* 6 miles west of Custer. *Ownership:* J. P. McKenna, Custer, S. Dak. *Property:* 3 unpatented claims, approximately 60 acres. *Type of Deposit:* Fissure vein. *Ore:* Free gold in a gangue of Hornblende and quartz. *Development:* 100' shaft and 75' of drifts. *Remarks:* This is a prospect only. Idle at the present time, except for assessment work.

NEW YORK MICA MINE: *Location:* Near Custer. *Type of Deposit:* Pegmatite. *Valuable Minerals:* Beryl, Mica. *References:* (4) (5) (13) (19).

NORTH STAR: See the Hard Scrabble.

OCCIDENTAL: *Type of Deposit:* A pegmatite. *Ore:* Tin. *References:* (1) (5).

OLD BILL MINE: *Location:* 5 miles northwest of Custer in unorganized mining district. *Ownership:* C. A. Clark, Fred Lovejoy, John Wilhelm, Rufus Wells, James

Starner, and John Merrit, Custer, S. Dak. *Property*: 10 patented claims, approximately 201 acres. *Type of Deposit*: Fissure vein in slate and schist. *Ore*: Gold and some Silver. *Development*: 2 shafts 80' and 55' in depth, some stoping and several open cuts. *Remarks*: 6 men doing development work on the property.

OLD JEFF CLAIM: *Location*: 5 miles northwest of Custer. *Type of Deposit*: Pegmatite. *Ore*: Tin. *Reference*: (2) (5).

OLD MIKE: See Great Northern Mica Mine.

PAYDAY LODGE: *Location*: In an unorganized mining district 1½ miles north of Pringle. *Ownership*: Mr. L. D. Pitts, Pringle, S. Dak. *Property*: 1 unpatented claim, approximately 20 acres. *Type of Deposit*: Pegmatite. *Valuable Minerals*: Mica, Beryl, and Feldspar. *Development*: By open cuts. *Remarks*: Assessment work only.

PENOBSCOT MINE: *Location*: 6 miles west of Custer. *Type of Deposit*: Small quartz stringers in pre-Cambrian slates and schist. *Ore*: Gold and Silver. *Remarks*: Operated for a short time during 1935. *Reference*: (21).

PEERLESS MINING CO.: *Location*: On French Creek near Custer. *Equipment*: 1½ cu. yd. power shovel and four 36" Ainalay Centrifugal bowls. *Remarks*: Operated for a short time during summer of 1934, then moved to Park County, Colo. *Reference*: (20).

PHELPS SPAR: *Location*: 5 miles east of Custer. *Ownership*: Francis Michaud and John Phelps, Custer, S. Dak. *Property*: 1 claim, approximately 20 acres. *Type of Deposit*: Pegmatite. *Valuable Mineral*: Feldspar. *Development*: Open cuts, dike exposed for a distance of 300' along strike. *Remarks*: Prospect only.

PHILIP GEERING PROSPECT: *Location*: 2¾ miles southwest of Custer. *Type of Deposit*: Pegmatite. *Ore*: Tungsten. *Reference*: (4).

POLAR BEAR LODGE: *Location:* 2 miles south of Custer. *Ownership:* Floyd Hemen and Fred Heidepreim, Custer, S. Dak. *Property:* 1 unpatented claim, approximately 20 acres. *Type of Deposit:* Pegmatite. *Valuable Minerals:* Feldspar, Beryl, and Mica. *Development:* Several open cuts. *Remarks:* Prospect only.



Figure 14. The Reitz & Crites Sand Plant at Hermosa.

REITZ AND CRITES SAND CO.: *Location:* Plant at Hermosa. (This company also has a plant at Oral, S. Dak., Fall River Co., which see.) *Remarks:* Plant at Hermosa built on same principal as Oral plant, has annual capacity of 10,000 tons. Mining done by power shovel.

ROOSEVELT: See the Rough Rider.

ROSS AND WEATHERFIELD: See Ross Placer.

ROSS PLACER: Formerly Ross and Weatherfield. *Location:* 4½ miles northwest of Custer, on French Creek. *Ownership:* Mr. John Ross, Custer, S. Dak. *Property:* 1 unpatented claim, approximately 20 acres. *Type of Deposit:* Ancient gravel bed. *Ore:* Gold. *Equipment:* Dragline, trommel and sluices. *Remarks:* Operated during summer of 1935.

ROUGH RIDER: Formerly the Roosevelt Lode. *Location:* 11

miles west of Custer in an unorganized mining district. *Ownership*: Mr. M. J. Kelly and Margaret E. Williams, Custer, S. Dak. *Property*: 4 unpatented claims, approximately 60 acres. *Type of Deposit*: Fissure vein. *Ore*: Gold and some Silver. *Development*: 4 shafts, 175' 25' and two 40' in depth, also 500 sq. ft. of open cuts. *Remarks*: Now under option, intermittent exploration work being carried on.

ROYAL FLUSH AND DUBUQUE CLAIMS: *Location*: Near Custer. *Type of Deposit*: Pegmatite. *Valuable Mineral*: Beryl. *Reference*: (19).

RUSSELL: *Location*: 5 miles southwest of Custer. *Type of Deposit*: Pegmatite. Worked for mica. *Reference*: (5).

SAGINAW MINE: See Gold Reserve.



Figure 15. The F. E. Schundler Feldspar Plant at Custer

SCHUNDLER FELDSPAR PLANT: *Location*: At Custer. *Ownership*: F. E. Schundler Feldspar Co., Inc. *Local Rep-*

representative: Harold Eyrick. *Remarks*: Plant recently completed. Has a capacity of approximately 40 tons per day.

SCOTT ROSE QUARTZ MINE: *Location*: 8½ miles south-east of Custer, in an unorganized mining district. *Local Representative*: Frank Scott, Custer, S. Dak. *Ownership*: G. W. Scott, Golden, Colorado. *Property*: 1 unpatented claim, approximately 20 acres. *Type of Deposit*: Pegmatite. *Valuable Minerals*: Rose Quartz, Mica, Beryl, Feldspar, Tourmaline, small amounts of Spodumene and Amblygonite. *Development*: Several open cuts. *Remarks*: Exploration work being done at present; has produced considerable amount of ornamental stone.

SKOOKUM PLACER: *Location*: 2½ miles east of Custer in an unorganized mining district. *Ownership*: Jake W. Wilson, Custer, S. Dak. *Property*: 1 unpatented claim, approximately 20 acres. *Type of Deposit*: High bar and residual placer. *Ore*: Gold. *Development*: Trenching system employed. *Remarks*: 1 man employed doing exploration work.

SMITH RANCH: Leased by Rushmore Clay Products Co., Rapid City. *Location*: In an unorganized mining district, 7 miles north of Fairburn. *Ownership*: Vern Smith and Furman, Fairburn, S. Dak. *Property*: 1 patented claim, approximately 40 acres. *Type of Deposit*: Yellowish gritty clay, nodular structure, flat-lying deposit, 8' in depth. *Valuable Material*: Fuller's Earth. *Development*: Open pit method employed. *Remarks*: Not operating at present time due to lack of market.

SODA SPAR: *Location*: 4½ miles north of Pringle, in an unorganized mining district. *Ownership*: Mr. L. D. Pitts, Pringle, S. Dak. *Property*: 1 unpatented claim, approximately 20 acres. *Type of Deposit*: Pegmatite. *Valuable Minerals*: Soda-Feldspar, Beryl, Mica, Quartz, some Lithia minerals. *Development*: By open cuts. *Remarks*: Assessment work only. *Production*: 2 carloads of Mica Schist shipped to U.S. Mica Co., Forest Park, Illinois.

SPOKANE SILVER AND LEAD CO.: *Location:* 8 miles southeast of Keystone. *Officers:* William J. Clair, President, 1021 Campbell Avenue, Detroit, Mich.; J. A. Foerstner, Vice-President; T. A. Ferneding, Secretary and Treasurer; Executive Offices, Dayton Ohio. *Property:* Spokane and Cuyahoga mines in Custer County. *Valuable Minerals:* Lead, Zinc, Gold and some Silver, also Hematite, Graphite, Beryl, Mica, Arsenic and Copper. *Remarks:* At present time doing exploration work and contemplating diamond drilling the property.

SPRING CREEK PLACER: *Location:* 9 miles northwest of Custer in an unorganized mining district. *Representatives:* Messrs. Paige Tubbs and Gordon Doyle, (leasers) Custer, S. Dak., *Property:* Located on Tenderfoot gulch. *Type of Deposit:* Bar and creek placer. *Ore:* Gold. *Development:* Caved test holes show evidence of being worked by early day miners. A few test holes have been put down by present leasers. *Remarks:* Idle at present time.

ST. LOUIS MICA MINE: *Location:* 4½ miles southeast of Custer. *Type of Deposit:* Pegmatite. *Reference:* (4).

STRASSBERG AND THE GOLD HILL: *Location:* 8 miles northwest of Custer, in an unorganized mining district. *Ownership:* Mr. Frank A. Miller, Custer, S. Dak., and Annie V. Peacock, Tacoma, Washington. *Property:* 2 unpatented claims, approximately 40 acres. *Type of Deposit:* Quartz veins in pre-Cambrian slates and schist. *Ore:* Gold and some Silver. *Development:* By open cuts and four shafts, 25', 30', 50', and 80' in depth. *Remarks:* Assessment work only.

SUNNYSIDE CLAIM: *Location:* Near Custer. *Type of Deposit:* Pegmatite. *Valuable Mineral:* Beryl. *Reference:* (19).

TIN MOUNTAIN: Formerly owned by H. W. Fowler. *Ownership:* Maywood Chemical Works, Maywood, N. J. *Location:* 5 miles west of Custer, on Warren's Gulch. *Ore:* Tin.



Figure 16. The Tin Mountain Mine of the Maywood Chemical Works near Custer

Remarks: Property being held as a reserve supply of lithia minerals. Idle at the present time. *Reference:* (15).

TIPTOP CLAIM: *Location:* Near Custer. *Type of Deposit:* Pegmatite. *Valuable Mineral:* Beryl. *Reference:* (19).

TURK MINE: *Location:* 5 miles west of Custer, in an unorganized mining district. *Ownership:* Mr. L. McKenna and partners, Custer, S. Dak. *Property:* 6 unpatented claims, approximately 60 acres. *Type of Deposit:* Shear Zone. *Ore:* Gold and some Silver. *Development:* One 75' shaft. *Mine Plant:* Air compressor, Jackhammer, hose, drills, one hoist, car and steel rails. *Power:* 3 HP engine to operate pump. *Remarks:* Idle since 1934. Recently examined for RFC loan.

VICTOR LODGE: *Location:* In an unorganized mining district near Keystone. *Ownership:* Vincent Judd, C. H. Mooney, M. J. Scanlan and Marcia Scanlan, all of Hermosa, S. Dak. *Property:* Five claims, Victor Lodge, New Year Lodge, Mizpah Lodge, Katharine Lodge, and Hamberg Lodge, aggregating approximately 100 acres of unpatented ground. *Type of*

Deposit: Pegmatite. *Valuable Minerals:* Feldspar, Mica, Beryl and some Columbite. *Development:* Open cut. *Remarks:* Two men employed doing development work.

WARREN MICA: *Location:* Near Custer. *Type of Deposit:* Pegmatite. *Reference:* (13)

WHITE ELEPHANT MINE: *Location:* 5 miles N.W. of Pringle. *Ownership:* Abingdon Sanitary Mfg. Co., Abingdon, Ill. *Type of Deposit:* Pegmatite. *Valuable Mineral:* Feldspar. *Remarks:* Operating at present.

WHITE SPAR: *Location:* Near Custer. *Type of Deposit:* Pegmatite. *Valuable Minerals:* Beryl and mica. *References:* (4) (5) (19).

WILD ROSE MINE: Formerly the Grant Lode. *Location:* 3½ miles northeast of Custer, in an unorganized mining district. *Ownership:* S. H. Keoughan, Trustee, Casper, Wyoming. *Property:* 3 unpatented claims, approximately 60 acres. *Type of Deposit:* Quartz vein in slate and schist associated with pegmatite. *Ore:* Gold and some Silver. *Development:* 100' shaft, 697' of drifting and crosscutting, several open cuts. *Mine Plant:* Ingersoll-Rand compressor, —250 cu. ft. per min.; a two-stage compressor; Chicago Pneumatic air compressor—450 cu. ft. per min.; Ingersoll-Rand drill sharpener; 10 HP gas hoist; Cameron No. 7 sinker; 1-150 KW generator. *Mill:* Mosely dry-grinding mill and 50-ton ball mill. *Power:* Gas-electric. *Production:* Nov., 1934 to the present, 120 tons mined. *Remarks:* 5 men employed doing exploration work.

WINDOW LIGHT: *Location:* 5½ miles southwest of Custer. *Type of Deposit:* Pegmatite. *Valuable Mineral:* Mica. *References:* (5) (13).

WYOMING MICA LODGE: *Location:* 5¾ miles southwest of Custer. *Ownership:* F. T. Peterson. *Type of Deposit:* Pegmatite. *Valuable Mineral:* Mica. *Reference:* (4).

Dewey County

BUTLER COAL PROPERTY: *Location:* Near Timber Lake.
Ownership: L. L. Butler, Timber Lake, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal.
Remarks: Reported out of business, 1928.

BUTTRICK COAL PROPERTY: *Location:* Near Isabel.
Ownership: F. L. Buttrick, Isabel, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal.
Remarks: On Bureau of Mines List, 1925.

CARTER, WEST AND BURNITE COAL CO.: See Firesteel.

FAILLES COAL PROPERTY: *Location:* Near Firesteel.
Ownership: Allen Failles, Firesteel, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal.
Remarks: Out of business, 1933.

FIRESTEEL COAL PROPERTY: Formerly Carter and West and Burnite Coal Co. *Location:* Firesteel. *Ownership:* Firesteel Coal Company. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal.

HAMMERLY COAL PROPERTY: *Location:* Firesteel.
Ownership: Hammerly Coal Company. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal.

HAMMOND COAL PROPERTY: *Location:* Near Isabel.
Ownership: Frank Hammond, Isabel, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal.

HEYL AND DALEY COAL PROPERTY: *Location:* Near Isabel. *Ownership:* Heyl and Daley, Isabel, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal. *Remarks:* Abandoned in 1929.

ISABEL COAL CO. PROPERTY: *Location:* Near Isabel.
Ownership: Isabel Coal Co. (Paul Nazey, Isabel, S. Dak.)
Type of Deposit: Flat-lying beds. *Valuable Mineral:* Lignite coal.

JOHNSON COAL PROPERTY: *Location:* Near Isabel.

Ownership: Anna Johnson, Isabel S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal. *Remarks:* Out of business, 1927.

JORDEN COAL PROPERTY: *Location:* Isabel, S. Dak. *Ownership:* Ottis Jorden, Isabel, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal. *Remarks:* Abandoned 1929.

MARTIN & ELLIS (Ellis Mining Co.): *Location:* Near Isabel. *Ownership:* Martin & Ellis. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal. *Remarks:* Ellis Mining Company out of business in 1930.

MUNSON COAL PROPERTY: *Location:* Near Firesteel. *Ownership:* C. R. Munson, Firesteel, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal. *Remarks:* Letters from Bureau of Mines returned 1927.

PLAFF-MILLS COAL CO.: See Robbins Mining Co.

RAYMOND COAL PROPERTY: *Location:* Near Isabel. *Ownership:* R. A. Raymond, Isabel, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal. *Remarks:* Abandoned 1929.

REICHERT COAL PROPERTY: *Location:* Near Isabel. *Ownership:* Peter Reichert, Isabel, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal.

ROBBINS COAL COMPANY: Formerly Plaff-Mills Coal Co. *Location:* Isabel, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal. *Remarks:* Letters from Bureau of Mines returned 1923.

ROGGENCAMP COAL PROPERTY: *Location:* Near Firesteel. *Ownership:* H. G. Roggencamp, Firesteel, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal. *Remarks:* Letters from Bureau of Mines returned 1926.

ROZANDER-TIDBALL COAL PROPERTY: *Location:* Near Isabel. *Ownership:* Oscar Rozander, T. B. Tidball, Isabel,

S. Dak. *Type of Deposit*: Flat-lying beds. *Valuable Mineral*: Lignite coal.

S. DAK. COAL COMM. (Geo. Puder Comm.): *Location*: Firesteel, S. Dak.

Edmunds County

IPSWICH SAND AND GRAVEL CO.: *Location*: Ipswich, S. Dak. *Owner and Supt.*: J. W. Parmley, Ipswich, S. Dak. *Valuable Material*: Sand. *Annual Production*: 100,000 tons. *Mine Plant*: Dragline and conveyors. *Mill Plant*: Screens and washer. *Remarks*: Worked out and operation ceased.

Fall River County

EVANS QUARRY AND BURKE QUARRY: Formerly the Evans Quarry. *Location*: In an unorganized district, 5 miles south of Hot Springs. *Local Representative and President*: Henry Bering, Hot Springs, S. Dak. *Incorporated*: In S. Dak. June, 1930. *Capital Stock*: 100 shares preferred stock with a par value of \$10.00 per share, 500 shares preferred stock with a par value of \$10.00 per share, \$5,000 preferred stock and \$3,400 of common stock sold. *Property*: 2 patented claims, approximately 540 acres. *Type of Deposit*: Flat bed overlain with gravel. *Valuable Material*: Dakota Sandstone. *Development*: Channeling followed by plug and feathering. *Treatment Plant*: Gang saws, circular saws and planer. *Power*: Central West Public Service Co. *Production*: 1934-\$35,000. (\$1.50 to \$4.00 per cu. ft. for cut.) *Remarks*: Operating, employing 18 men.

GRANT ROBINSON'S PROPERTY: Formerly the Baker Plaster Co.; the Hot Springs Plaster Co., and the U. S. Gypsum Co. *Location*: In an unorganized mining district, 1 mile west of Hot Springs. *Ownership*: Mr. Grant Robinson, Hot Springs, S. Dak. *Property*: Approximately 20 acres patented. *Type of Deposit*: Gypsum interbedded in red shale. *Valuable Mineral*: Alabaster gypsum. *Development*: Stepped-face quarry method employed. *Remarks*: Idle during the past 30 years.

HOT SPRINGS GYPSUM CO.: *Location:* At Erskine, 3 miles west of Hot Springs. *Type of Deposit:* Flat veins interbedded with Spearfish "Red Beds". *Valuable Material:* Gypsum. *Remarks:* Plant a failure and now dismantled.

HOT SPRINGS PLASTER CO.: See Grant Robinson's Property.

JIM HILL: *Location:* In an unorganized mining district, 10 miles southeast of Edgemont. *Ownership:* Lee Lawson, Rumford, S. Dak. *Type of Deposit:* Flat, interbedded with Lakota Sandstone. *Ore:* Bituminous coal. *Development:* 230' of inclines, 180' of drifts. *Treatment:* Large pieces of slate removed by hand sorting. *Production:* 1918-1919 approximately 5,000 tons of coal at \$18.00 ton, 1934-1935, 600 tons at \$3.50 ton. *Remarks:* Idle since the spring of 1935.

NATIONAL ALABASTER CO.: *Location:* At Alabaster near Hot Springs, S. Dak. *Type of Deposit:* Flat veins interbedded with Spearfish "Red Beds". *Valuable Material:* Gypsum. *Remarks:* Operated but a short time, plant now dismantled.

OLD EVANS QUARRY: See Evans and Burke Quarry.



Figure 17. The Bentonite Mine of the Refinite Company at Ardmore.

REFINITE CO.: *Location:* Plant in the town of Ardmore, de-

posit located 2 miles north and west of Ardmore. *Local Representative:* J. D. Wherry, Ardmore, S. Dak. *Officers:* President, Mr. T. E. Stevens, 1023 Harney St., Omaha, Nebr., Secretary, Mr. E. H. Bauman. *Incorporated:* Delaware, 1919. *Capital Stock:* Par value \$100.00; 15,859 shares issued. *Property:* Mines and factory in Fall River County. *Type of Deposit:* Thin vein interbedded in Pierre shale. *Valuable Material:* Ardmoreite (a bentonite). *Development:* Open cut method employed. *Mill:* One hammer mill, one dryer, one roller mill and sifter, one calciner. *Power:* Steam-electric. *Production:* 1917-1928, 16,825 tons raw ardmoreite having a value as mined of \$52,190. *Remarks:* Operating and employing 14 men.



Figure 18. The Reitz & Crites Sand Plant at Oral

REITZ AND CRITES SAND CO.: *Location:* Oral, S. Dak.

This company also has a plant at Hermosa, Custer County, which see. *Officers:* P. A. Reitz, Chadron, Nebr., President; E. D. Crites, Secretary; C. C. Reitz, Mgr., Rapid City, S. D. *Incorporated:* South Dakota and Nebraska, April 1, 1927. *Capital Stock:* 435½ shares of \$100 par value. *Type of Deposit:* Sand and gravel bar lying on Pierre shales, immediately south of the Cheyenne River. *Valuable Material:* Sand

and Gravel. *Mine Plant*: Dragline, conveyors. *Treatment Plant*: Washer and screens. *Annual Production*: Over 50,000 tons. *Remarks*: Operating intermittently, employing 12 men.

Grant County

MILBANK MAHONGANY GRANITE WORKS: See the Robert Hunter Granite Company.

ROBERT HUNTER GRANITE COMPANY: Formerly the Milbank Mahogany Granite Works. *Location*: Milbank, S. Dak. *Type of Deposit*: Pre-Cambrian granite. *Valuable Mineral*: Mahogany-colored granite of monumental quality. *Annual Production*: In excess of \$150,000.

Hanson County

CONSOLIDATED SAND AND STONE CO.: Formerly the Spencer Quarry. *Location*: 1 mile west and 1 mile south of Spencer, S. Dak., in Edgerton townships, Hanson County. For sand and gravel see under Minnehaha County. *Ownership*: Consolidated Sand and Stone Co., Sioux Falls, S. Dak. *Incorporated*: In South Dakota. *Officers*: Wm. Hoese, President; W. A. Barnhart, Vice-President; Delbert Wheeler, Secretary-Manager. *Property*: 160 acres of stone land. *Type of Deposit*: Pre-Cambrian quartzite. *Valuable Mineral*: Sioux Quartzite, known as "Sioux Falls Granite". *Plant*: Crushing plant of 50,000 tons annual capacity. Additional rip-rap capacity, 100,000 tons. *Production*: 400,000 tons crushed stone to date. *Remarks*: Operating, employing 70 men.

SPENCER QUARRY: See Consolidated Sand and Stone Co.

Harding County

CAVE HILLS COAL MINE: *Location*: Buffalo, S. Dak. *Type of Deposit*: Flat-lying beds. *Valuable Mineral*: Lignite coal. *Remarks*: Letters returned unclaimed 1934-35.

COFFIELD COAL PROPERTY: *Location*: Near Reva.

Ownership: Edgar P. Coffield, Reva, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal.

EVAN JOHNSON COAL PROPERTY: *Location:* 4½ miles from Ludlow. *Ownership:* Evan Johnson, Ludlow, S. Dak. Formerly owned by W. A. Pelham. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal. *Remarks:* Mined by stripping process.

GIONNONATTI COAL PROPERTY: *Location:* Near Ludlow. *Ownership:* A. H. (John) Gionnonatti, Ludlow, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal.

HODGE COAL PROPERTY: *Location:* Near Reva. *Ownership:* James Hodges, Reva, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal.

MITCHELL COAL MINE: *Location:* Near Reva, S. Dak. *Ownership:* Bud Mitchell, Reva, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal. *Remarks:* Abandoned 1929.

POLJANSEK COAL PROPERTY: *Location:* Near Ralph. *Ownership:* Poljansek Bros. Ralph, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal.

SHIRLEY COAL COMPANY: *Location:* Ralph, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal.

SKOBERNE-PINTAR COAL PROPERTY: *Location:* Near Ralph. *Ownership:* Joe Skoberne, Joe Pintar, Ralph, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal.

Lawrence County

ABUNDANCE MINING CO.: See Winner Mining Co.

AMA QUEEN GOLD MINING COMPANY: *Location:* 14 miles southeast of Deadwood, near Pactola. *Ownership:* Ama Queen Gold Mining Company. *Local Representative:*

J. Chas. Sherman, Pactola, S. Dak. *Incorporated:* South Dakota, 1896. *Capital Stock:* 1,500,000 shares. *Par Value:* \$1.00; 1,015,000 shares issued. *Property:* 13 unpatented claims, approximately 260 acres. *Type of Deposit:* Fissure vein in pre-Cambrian schist. *Ore:* Gold and some Silver. *Development:* 75' shaft and 42' of drifting. *Remarks:* Assessment work only. Idle since 1907.

AMERICAN AND CLEVELAND TIN MINING COMPANY:
Now the Black Hills Tin Co., which see.



Figure 19. The Clover Leaf Mine of the Anaconda Gold Mine and Milling Company at Roubalx.

ANACONDA GOLD MINING AND MILLING COMPANY:

Formerly the Clover Leaf Mine and Uncle Sam Mine. *Location:* In the Bear Butte Mining District, 12 miles south of Deadwood. *Ownership:* Under lease to Anaconda Gold Mining and Milling Co. *Local Representative:* Martin H. Brede, Lead, S. Dak., President. *Other Officers:* D. M. Patterson, Chamber of Commerce Bldg., Denver, Colo., Secretary. *Incorporated:* South Dakota, Feb. 27, 1928. *Capital Stock:* 2,000,000 shares. *Par Value:* \$1.00. *Stock Issued:* 876,000 shares. *Property:* 600 acres unpatented and 1,600

acres patented, including lease and purchase option on Clover Leaf Mine. *Type of Deposit:* Quartz lenses in schist. *Ore:* Gold and some Silver. *Development:* 700' vertical shaft, 560' shaft, 6,340' of drifting and some crosscutting. *Mine Plant:* One first motion 2-drum hoist, 1000' capacity; one steam winch with 1,500' of 1" cable, two Pomona unwatering pumps—1,800 G.P.M. at 200' and 800 G.P.M. at 350'. *Power:* 500 HP in 2 Diesel units 330 KVA., 650 HP boiler plant with 5 boilers. Daily consumption 200 HP. Source of water is Elk Creek. *Remarks:* Worked 1889-1905 continuously. Development work being done on Clover Leaf Mine at present and ten stamps operating.

ANCHOR MOUNTAIN MINING CO.: *Location:* 5 miles east of Deadwood and 1½ miles north of Galena, S. Dak. *Incorporated:* South Dakota. *Capital Stock:* 2,000,000 shares. *Par Value:* \$1.00. *Officers:* Thos. Houlette, 2509 Arrott Bldg., Pittsburgh, Pa., President; John Cihak, Vice Pres.; Percy G. Houlette, Secretary. *Other Directors:* Thomas Boulger and Joe Tueck. *Property:* 780 acres including Aurum Group of 18 claims, 360 acres. *Type of Deposit:* Replacement in Deadwood formation and verticals. *Ore:* Gold and some Silver. *Development:* By 150' shaft and 1,200' of lateral workings. *Remarks:* Idle at present time. Examined for RFC loan.

ANNIE CREEK MINING COMPANY: Formerly the New Reliance Mining Company. *Location:* In the Bald Mountain District, 3½ miles west of Lead. *Local Representative:* Hayes and Hayes Law Firm, Deadwood, S. Dak. *Officers:* E. B. Whitman, Minneapolis, Minn., Pres.; L. A. Sorenson, New York City, Vice Pres.; C. O. Veker, Minneapolis, Minn., Sec.-Treas.; *Other Directors:* D. D. Baldwin, Carthage, A. C. Boles, New York City; H. C. Kiser, New York City; S. P. Whitmore, Omaha, Nebr. *Incorporated:* South Dakota, 1922. *Capital Stock:* 500,000 shares having a par value of \$1.00; 300,000 shares issued. *Property:* 35 claims and fractions, all patented, totalling 288 acres. *Type of Deposit:* Replacement in dolomitic members of Cambrian sediments,

and some important vertical ores cutting through the same. *Ore*: Gold and some Silver. *Development*: By tunnels. *Mill*: 30-stamp mill, sand-lime cyanidation, 100 tons new capacity. *Power*: Connected with the Consolidated Electric Co. line, Deadwood, S. D. *Production*: Prior to mill shutdown in 1916, \$610,284.00 *Remarks*: This property was diamond drilled through lower contact horizon; exploration and sampling of property in 1935; under development at present.

AUGUST SCHEDINE PLANT: *Location*: Near east city limits of Deadwood. *Valuable Mineral*: Limestone. *Remarks*: Operated in early days. Only the foundation for old kiln remains. *Reference*: (17).

BALD MOUNTAIN MINING COMPANY: Formerly the Portland Mining Company, and Trojan Mining Company. *Location*: Trojan, S. Dak. *Local Representative*: C. E. Dawson, Trojan, S. Dak. *Officers*: O. D. Collis, President, Clinton, Iowa. E. J. Curtis, Secretary, Clinton, Iowa. *Incorporated*: South Dakota, 1929. *Capital Stock*: 750,000 shares Class A., par value \$1.00; 1,500,000 shares Class B., no par value. *Operating Personnel*: C. E. Dawson, General Manager, H. Slaughter, Mine Superintendent; N. P. Goodrich, Mill Superintendent. *Property*: 306 patented claims approximately 2,250 acres. *Type of Deposit*: Cambrian flat beds. *Ore*: Gold and some Silver. *Development*: Adits, drifts, crosscuts, raises, and winzes. *Mine Plant*: Compressors, drill, hoists, tracks, cars, etc. *Mill*: 200-ton cyanide. *Power*: Electric. *Production*: 86,760 tons mined and milled in 1935. *Remarks*: Operating, employing 80 men.

BEAR CREEK: *Location*: In Tinton district. *Valuable Mineral*: Tin. *Reference*: (15).

BEAR GULCH AND GOLD HILL MINING COMPANY: *Valuable Mineral*: Tin. *Reference*: (15).

BEAVER CREEK MINE: Formerly the Lineal Lodes. *Loca-*

tion: 13 miles southwest of Spearfish, in the Rawlins Mining District. *Officers:* W. O. Fillmore, President, Spearfish, S. Dak.; F. E. Jarosh, Secretary, Omaha, Nebraska. *Incorporated:* South Dakota, June 1, 1934. *Capital Stock:* 10,000 shares. *Stock Issued:* 1,500 shares at \$10.00 a share. *Property:* 11 patented claims, approximately 220 acres. *Type of Deposit:* Replacement. *Ore:* Gold and some Silver. *Development:* 125' shaft and 150' of drifting. *Mine Plant:* 45 gal. per minute centrifugal pump driven by a 5 HP motor. One 500 gal. per min. plunger type pump; one 45 gal. per min. two cylinder steam pump driven by a 5 HP motor; one 65 gal. per min. double action pump; 100' of rail and one steel car for tramping. One steam hoist, 110 HP, 11' drum. *Power:* Steam and Delco light system. *Remarks:* Eight men doing exploration work during summer of 1935.

BELLE ELDRIDGE GOLD MINES: *Location:* 1½ miles east of Deadwood, S. Dak., in the Whitewood mining district. *Officers:* A. J. Dunn, President; J. W. Dunn, Secretary; Deadwood, S. Dak., Box 255. *Incorporated:* South Dakota, 1935. *Capital Stock:* 50,000 shares of \$1.00 par value. *Property:* 2 claims and a fraction, approximately 50 acres unpatented. *Type of Deposit:* Replacement in Cambrian Sediments. *Ore:* Gold and some Silver. *Development:* 3,000' tunnels and drifts. *Remarks:* Financing at the present time.

BEN HUR: Formerly the Wall Street, Ben Hur—Christopher. *Location:* In the Whitewood Mining District, 7 miles southeast of Deadwood. *Ownership:* Mr. Thomas Thomas, Deadwood, S. Dak. *Property:* 3 unpatented claims approximately 50 acres. *Type of Deposit:* Replacement in Cambrian sediments. *Ore:* Gold and some Silver. *Development:* Shaft 100' in depth, 310' tunnel, 50' winze in tunnel, 350' of drifting and crosscutting. *Remarks:* Assessment work only.

BERG PROSPECT: *Location:* 7 miles southeast of Deadwood in Whitewood Mining District. *Ownership:* August Berg and Elda Berg, Deadwood, S. Dak. *Property:* 3 unpatented claims, approximately 50 acres. *Type of Deposit:* Replace-

ment in Cambrian sediments. *Ore*: Gold and some Silver. *Development*: By a 600' tunnel. *Remarks*: Assessment work only.

BEST PLACER: *Location*: In the Whitewood Mining District, 5 miles south of Whitewood, in Deadwood Gulch. *Ownership*: Albert Best, Whitewood, S. Dak. *Property*: 40 acres of patented land under lease. *Type of Deposit*: Gulch placer. *Ore*: Gold. *Development*: Stripping and open cuts. *Remarks*: S. C. Muir, leaser working here with a 1½ cu. yd. dragline, and revolving sluice during summer of 1935.

BIG RED AND DAUNTLESS: *Location*: In the Ida Gray Mining District, 5 miles west of Deadwood. *Ownership*: Ernest Mueller, Deadwood, S. Dak. *Property*: 2 unpatented claims, approximately 40 acres. *Type of Deposit*: Replacement in Deadwood formation. *Ore*: Gold and some Silver. *Development*: Developed by tunneling. *Remarks*: Assessment work only.

BISMARCK CONSOLIDATED MINING COMPANY: *Ore*: Tungsten and Gold. See Bismarck Mine.

BISMARCK MINE: Formerly owned by the Bismarck Consolidated Mining Co. *Location*: North of and adjacent to the Wasp No. 2 Mill. *Type of Deposit*: Replacement in the lower dolomites of the Deadwood formation, and to some extent in the basal quartzite. *Ore*: Tungsten and Gold. *Remarks*: Deposits have produced a small quantity of tungsten, but tungsten ore is known to occur over an area of 6 to 8 acres. *Reference*: (16).

BLACK HILLS EXPLORATION COMPANY: Property located 3 miles south of Lead. *Officers*: Sid Grauman, President & Treasurer; Al Jolson, V. Pres. & Chairman. *Board of Directors*: H. H. Stowell, V. Pres. & Gen. Mgr. Executive Offices, 6925 Hollywood Blvd., Los Angeles, Calif. Resident Counsel, John R. Russell, Deadwood, S. D. *Property*: Have lease on 3,000 acres of patented mining claims. *Ore*: Gold and some Silver. *Remarks*: Idle at the present time; were diamond drilling during the summer of 1936.

BLACK HILLS MINING CORPORATION: Formerly the Monarch Mining Company. *Location:* 7 miles southeast of Deadwood in the Whitewood Mining District. *Local Representative:* Bancroft Gore, Rapid City, S. Dak. *Officers:* William Erickson, Mgr. and President; Deadwood, S. Dak.; E. Whitney, Secretary, 529 Second Ave., Minneapolis, Minn. *Incorporated:* South Dakota, 1932. *Capital Stock:* 500 shares of \$100.00 par value all issued. *Property:* 6 patented claims, approximately 56 acres. *Type of Deposit:* Porphyry ore and replacement in Cambrian sediments. *Ore:* Gold and some Silver. *Development:* 125' shaft and 3,000' of drifting and crosscutting. *Mine Plant:* ½ ton electric hoist, 20 HP air compressor, triplex pump and 2 small centrifugal pumps. Mine is partially equipped with electric lights. *Mill:* 15-ton cyanide plant. *Power:* Electric from Consolidated line. *Production:* 1912-1917—\$22,000; 1933—Oct. 1935, \$48,000. *Remarks:* Idle at present time.

BLACK HILLS TIN COMPANY: Formerly the American and Cleveland Tin Mining Co., Tinton Tin Mining Co., and Tinton Reduction Co. *Location:* 11 miles northwest of Deadwood, in the Tinton Mining District. *Officers:* J. L. Beatty, President, 9705 Cottage Grove, Chicago, Ill., Ross J. Beatty, Jr., One N. LaSalle St., Chicago, Illinois, Secretary. *Incorporated:* In Delaware, 1928. *Capital Stock:* 10,000 shares, \$100 par value. *Property:* 2,700 acres patented. *Type of Deposit:* Pegmatite. *Ore:* Tin, Tantalum, Amblygonite and Mica. *Development:* 3,000' of tunneling; 100' shaft and 70' lateral workings at 100' level; 180' shaft, which is inaccessible. *Mill:* 250-ton table concentration plant. *Power:* Diesel-electric. *Production:* 1903, \$14,000; some production 1904; 1909, \$4,832; 1910, \$13,600; 1927, \$200; 1928, approximately \$2,000. *Remarks:* Mill has been idle since 1929. Some development work was done in 1935. Doing development work at the present time. *Reference:* (15).

BRANCH MINT MINING COMPANY: See Hoodoo Group.

BROSNAHAN: *Location:* On Upper Two Bit Creek, Lawrence County. *Ore:* Tungsten. *Reference:* (16).

BROWN MANGANESE PROPERTY: *Location:* Near Deadwood, at the head of Strawberry Gulch. *Ownership:* Mr. and Mrs. James E. Brown, Deadwood, S. Dak. *Ore:* Manganese. *Remarks:* A prospect.

CANYON CORPORATION: Formerly the North Homestake Co., Penobscot Mining Co., and the Maitland Property. *Location:* 5 miles west of Deadwood in the Ida Gray Mining District. *Incorporated:* New Jersey, 1934. *Officers:* Mitchell Taradash, President, 1-Exchange Place, Jersey City, N. J. *Operating Staff:* L. B. Eames, General Supt., Maitland, S. Dak., Vic Sigman, Mine Supt.; Lloyd Banning, Mill Supt. *Property:* 25 patented claims, approximately 1,100 acres. *Type of Deposit:* Replacement in dolomite beds. *Ore:* Gold and some Silver. *Mine Plant:* Mine cars, electric hoist, Amco loader, blower for ventilation, 1,300 cu. ft.-200 HP compressor, 900 cu. ft.-125 HP compressor, 7-No. 75 Ingersoll-Rand drills, 1 jackhammer. *Mill:* Continuous Counter Current Decantation Cyanide mill preceded by preliminary roasting. *Tonnage:* 110 tons per day. *Power and Lighting:* Electric. *Development:* 1 shaft 620' in depth which is worked only to a depth of 320'; filled with water up to 320' level; 2 air shafts; 1—500' tunnel; 2 levels, 220' and 270'. Work at present is carried on at the 220' level, the 270' level to be opened up soon; 1 drift 2,000' in length. *Production:* Penobscot Mining Co., 1903; Alexander Maitland, 1904, 1905, 1906; North Homestake Mining Co., 1907-8, 1911. Development work 1912-13-14-15. Canyon Corp., 1935, 1936. *Remarks:* Operating, employing 85 men.

CLOVER LEAF MINE: See Anaconda Gold Mining and Milling Co.

COMSTOCK: *Location:* On Upper Two Bit Creek, Lawrence County. *Ore:* Tungsten. *Reference:* (16). Now part of S. R. Smith Group, which see.

CONSOLIDATED MANGANESE LODGE: *Location:* In un-

organized mining district, 18 miles northeast of Rochford. *Ownership*: Wm. McCoy, Custer, S. Dak., and Glen Miller, Box Butte County, Nebraska. *Property*: 1 unpatented claim, approximately 20 acres. *Type of Deposit*: Replacement. *Ore*: Manganese Oxide. *Development*: Open cut system employed. *Remarks*: Assessment work only.

CUSTER PEAK COPPER COMPANY: *Location*: Mine Address, Roubaix, S. Dak. *Ownership*: Custer Peak Copper Co. *Representative*: J. M. Yost and Co., 406 Fitzsimmons Bldg., Pittsburg, Pa. *President*: John H. O'Brien. *Incorporated*: South Dakota. *Capital Stock*: 3,000,000 shares. *Par Value*: \$1.00. *Shares Issued*: 100,400. *Property*: 2,900 acres, including the Jungle Mine at Roubaix. *Type of Deposit*: Porphyry dikes cutting schist. *Ore*: Copper. *Development*: 65', 90' and 300' shafts. *Power*: Steam. *Mine Plant*: Hoists, air compressor. *Mill*: 100-ton concentrator. *Remarks*: Development in 1919; idle since that time. *Reference*: (12).

CUTTING MINE: See National Gold Mining Company.

DAKOTA MAID: See Gilt Edge Mines, Inc.

DEAD-BROKE MINE: Formerly the Phoenix Gold Mining Co. *Location*: 3 miles west of Deadwood in the Whitewood Mining District. *Ownership*: Mr. Nathan Rosenthal, San Diego, Calif., and Mr. Carl H. Kubler, Deadwood, S. Dak. *Property*: 10 patented claims, approximately 107.54 acres. *Type of Deposit*: Conglomerate (Cement Ore). *Ore*: Gold and some Silver. *Development*: Approximately 1,100' of tunneling and 600' of crosscutting. *Remarks*: Idle since 1905.

DEADWOOD DEPOSIT: *Location*: In city of Deadwood. *Ore*: Tungsten. *References*: (9), (16).

DEADWOOD GOLD, INCORPORATED: Formerly the Golden Crest Consolidated Mining Co. *Location*: 8 miles southeast of Deadwood, in the Whitewood Mining District. *Officers*: R. Kenneth Lee, President; George W. Pitts, Gen. Motors Bldg., Detroit, Mich., Secretary and Treasurer. *Capi-*



Figure 20. The Golden Crest Mine of Deadwood Gold, Inc., near Deadwood

tal Stock: 100,000 shares of \$10 par value, all issued. *Property:* 6 patented claims and 9 unpatented claims. *Type of Deposit:* Porphyry ore and replacement in Cambrian sediments. *Ore:* Gold and some Silver. *Mine Plant:* Electric hoist, compressor, drills, pump, track and cars. *Buildings:* Fully equipped assay office, mine office, blacksmith shop, bunk house and boarding house. *Mill:* 300-ton cyanide plant. *Power:* Electric from Consolidated Line. *Development:* 330' shaft and approximately 4,500' of drifting and crosscutting. *Remarks:* Exploration and sampling at present time.

DEADWOOD-HEIDELBERG MINE: See Mascot Mine.

DEADWOOD ZINC AND LEAD COMPANY: *Location:* 1 mile east of Deadwood in the Whitewood Mining District. *Local Representative:* A. J. Dunn, Deadwood, S. Dak. *Officers:* M. B. Dunn, Secretary; A. J. Dunn, President; both of Deadwood, S. Dak. *Incorporated:* South Dakota, 1911. *Capital Stock:* 750,000 shares of \$1.00 par value, 250,000 shares issued. *Property:* 4 unpatented claims, approximately 80 acres. *Type of Deposit:* Porphyry ore and replacement in

Cambrian dolomite. *Ore*: Gold, Silver, Lead and Zinc. *Development*: By tunnels. *Mill*: 10 stamps and 3 concentrating tables. *Remarks*: Idle at the present time.

DENIS HENAULT CLAIMS: *Location*: On lower west Strawberry Creek. Formerly owned by Denis Henault. *Type of Deposit*: Wolframite with quartz and feldspar in a rhyolite dike. *Ore*: Tungsten, Zinc and Gold. *Development*: A 30-ft. tunnel and test pits. *Remarks*: A prospect. *Reference*: (16).

DOUBLE RAINBOW: Formerly the Richmond-Sitting Bull Mine. *Location*: In the Bear Butte District, Lawrence County. *Type of Deposit*: Replacement in sandy dolomite. *Ore*: Lead and Silver. *Development*: 350' tunnel driven in 1923. *Remarks*: Operated in 1930; a mill was constructed. Idle at the present time.

EAGLE BIRD: *Location*: On Squaw Creek, 2 miles below Trojan in Lawrence County. *Ore*: Gold and some Silver. *Reference*: (12).

ECHO MINING COMPANY: See Golden Mining Company.

EL DORADO GOLD MINING COMPANY: *Location*: In Lawrence County. *Ore*: Gold and some Silver.

ESMERALDA: *Location*: 2 miles northwest of Lead in the Whitewood Mining District. *Property*: 9 patented claims and fraction millsite comprising in all 64,608 acres. *Type of Deposit*: Cement ore deposit. *Ore*: Gold and some Silver. *Development*: Tunnels, drifts, and stopes.

ETTA MINE: *Location*: $\frac{3}{4}$ mile north-northwest of the Bismarck Mine in Lawrence County. (Not to be confused with the Etta Mine at Keystone, S. Dak., which is a producer of Spodumene). *Ownership*: Homestake Mining Co. *Property*: One patented claim. *Type of Deposit*: Replacement in lower dolomites of Deadwood formation, intimately associated with rhyolite porphyry. *Ore*: Tungsten and Gold. *Reference*: (9).

FREMONT FRACTION: *Location:* In Lawrence County.

Ore: Gold and Manganese. *Remarks:* Letters returned unclaimed from former address. *References:* (7) (8).

FRERICHS MINING CORPORATION: Formerly the Kiemer Gold Mining and Milling Company. *Location:* Adjoins the city limits of Deadwood on the south. *Officers:* D. A. Frerichs, President, Box 353, Deadwood, S. Dak., 20 East Jackson Blvd., Chicago, Illinois. *Property:* 16 patented claims, approximately 250 acres. *Type of Deposit:* Fissure vein in porphyry. *Ore:* Gold and some Silver. *Development:* 2,000 feet of lateral workings. *Remarks:* Exploration work carried on in 1934. Recently examined for RFC loan.



Figure 21. The Gilt Edge Glory Hole of Gilt Edge Mines, Inc., near Deadwood.

GILT EDGE MINES, INCORPORATED: Formerly the Gilt Edge Consolidated, Dakota Maid, Oro Fino, Gilt Edge

and Rattlesnake Jack. *Location:* In the Bear Butte Mining District, 7 miles southeast of Deadwood, S. Dak. *Ownership:* Mrs. Leslie Sansom. Property held under purchase option by the Gilt Edge Mines, Inc. *Local Representative:* H. W. Langley, Deadwood, S. Dak., President and Secretary; Alex C. Johnson, Vice President; John B. Greene, Treasurer. *Incorporated:* South Dakota, January, 1935. *Property:* Patented claims aggregating 381 acres. *Type of Deposit:* Brecciated porphyry and replacement. *Ore:* Gold and some Silver. *Development:* 3 shafts, 85', 300' and 75' in depth, several open cuts. *Mine Plant:* Air compressor and 3 machine drills, tugs, hoist and Cameron centrifugal pump. *Remarks:* Operating, fifty men erecting plant.

GLADIATOR MINE: See National Gold Mining Co.

GLADSTONE GROUP: *Location:* In the Ida Gray Mining District, 2 miles from Lead, S. Dak. *Local Representative:* Frank Allen, Deadwood, S. Dak. *Ownership:* A part of the Mogul Mining Company. *Property:* 2 patented claims, 17 acres. *Type of Deposit:* Replacement in Cambrian sediments. *Ore:* Gold and some Silver. *Development:* 700' of tunneling, 600' of crosscutting and several small open cuts. *Remarks:* Idle since 1914.

GOLD DOLLAR: *Location:* In Lawrence County. *Ore:* Gold and some Silver. *Reference:* (12).

GOLD MOUNTAIN MINING AND MILLING CO.: *Location:* In the Two Bit Mining District, 6 miles by road, east of Deadwood. *Incorporated:* In South Dakota. *Capital Stock:* 1,500,000 shares, of \$1.00 par value. *Local Representative:* John R. Russell, Deadwood, S. Dak. *Property:* 21 patented claims aggregating 211 acres. *Type of Deposit:* Verticals in Cambrian sediments. *Ore:* Gold and some Silver. *Development:* 185' shaft, tunnels, and open cuts. *Production:* 1892-1894: 75.5 tons of ore returned \$1,725.50 *Remarks:* Idle at present time.

GOLDEN CREST CONSOLIDATED MINING COMPANY:

See Deadwood Gold, Inc.

GOLDEN CROWN: *Location:* Near Lead. *Ownership:* Homestake Mining Company. *Ore:* Gold and some Silver.

GOLDEN MINING COMPANY: Formerly the Echo Mining Company. *Location:* In the Ida Gray Mining District, 5 miles west of Deadwood. *Local Representative:* Mr. Allen Burke, Deadwood, S. Dak. *Officers:* Willis Venable, President and Secretary, Barre, Vermont. *Incorporated:* South Dakota, 1928. *Capital Stock:* 1,000,000 shares having a par value of 50c. No stock issued. *Property:* 7 patented claims, aggregating 130 acres. *Type of Deposit:* Vertical formation. *Ore:* Gold and some Silver. *Development:* 2 shafts, 400' and 200' in depth, 1,400' of crosscutting. *Mine Plant:* 60 HP compressor, 334 cu. ft. per minute; complete set of drill steel, No. 75 Ingersoll leyner; 2-No. 75 Ingersoll sinkers; 2 steel cars and 1,000' of track No. 12 rail; 60 HP Hendrie and Boltoff hoist complete with cable. Blower type fan; 1 Ingersoll Cameron 3-stage centrifugal pump; 75 HP 300 G.P.M. Gould—14 HP with a 300' lift. Also a Meyers-Bulldozer-Sinker, 200' lift, 45 G.P.M. *Power:* Electric from Consolidated lines. *Remarks:* Now being examined and development work in progress.

GOLDEN REWARD CONSOLIDATED GOLD MINING AND MILLING COMPANY: *Location:* In the Bear Butte and Whitewood Mining Districts at Terry. *Officers:* C. T. Tegethoff, New York City, President; N. E. Franklin, Deadwood, S. Dak., Secretary. *Incorporated:* South Dakota, 1895. *Capital Stock:* 1,000,000, shares having a par value of \$10.00; stock issued to 1916—841,793 shares. *Property:* 442 patented claims, approximately 3,391 acres. *Type of Deposit:* Replacement in Cambrian sediments. *Ore:* Gold and some Silver. *Development:* By tunnels and vertical shafts from 100—350' in depth. Workings total 15 miles. *Mine Plant:* Double drum hoist, compressor. *Mill Plant:* A 75-ton roaster. *Power:* Electrical. *Total Production:* Approximately \$20,000,000. *Remarks:* Idle since April, 1918.

Plant dismantled. At present, making a geological survey of property.

GOLDEN SUMMIT CLAIM: *Location:* Near Lead. *Ownership:* Homestake Mining Company. *Ore:* Tungsten and Gold. *Reference:* (16).

GOLDSTONE MINING COMPANY: Formerly the Keystone Mines. *Location:* Ida Gray Mining District, 4 miles west of Deadwood. *Local Representative:* (and President) Mr. S. D. Burns, Lead, S. Dak. *Secretary:* R. L. Ewing, Deadwood, S. Dak. *Incorporated:* South Dakota, Oct. 18, 1919. *Capital Stock:* 125,000 shares having a par value of \$1.00; 93,000 shares issued. *Property:* 8 patented claims, approximately 75 acres, and 2 unpatented claims, approximately 30 acres. *Type of Deposit:* Replacement in Cambrian sediments. *Ore:* Gold and some Silver. *Development:* 850' tunnel and several open cuts. *Remarks:* Idle since 1897.

GRANT CLAIM: *Location:* Near Lead. *Ownership:* Homestake Mining Company. *Ore:* Tungsten and Gold. *Reference:* (16).

HAILSTORM GROUP: *Location:* Near Lead. *Ore:* Gold and some Silver. *Reference:* (6).

HARRISON AND DURANGO CLAIMS: *Location:* Near Lead. *Ownership:* Homestake Mining Company. *Ore:* Tungsten and Gold. *Reference:* (16).

H. H. LEWIS QUARRY: *Location:* 1½ miles south of Spearfish. *Present Ownership:* H. H. Lewis. *Type of Deposit:* Flat bed with little overburden. *Valuable Material:* Minnekahta limestone. *Development:* Open pit quarry. *Treatment Plant:* A very small kiln. *Production:* 1900—1928 average about 4,000 bushels of lime per year. *Remarks:* Idle at the present time.

HIDDEN FORTUNE CLAIM: *Location:* Near Lead. *Ownership:* Homestake Mining Company. *Ore:* Tungsten and Gold. *Reference:* (16).

HIDDEN TREASURE GOLD MINING CO.: See Hoosier Mining and Milling Co.



Black Hills Studios, Inc., Lead

Figure 22. The Homestake Open Cut at Lead.

HOMESTAKE MINING COMPANY: *Location:* Mine at Lead in Lawrence County. Main Office,—910 American National Bank Building, San Francisco, California. Eastern Office,—15 Broad Street, New York. *Officers:* In San Francisco,—Edward H. Clark, President; Fred T. Elsey, Vice President; Richard A. Clark, Secretary; Charles B. Greeley, William Letson, and William Murray, Directors. In New York,—Campbell Locke, Treasurer. *Operating Staff:* In Lead, Guy N. Bjorge, General Manager; Allan J. Clark, Metallurgist; Chambers Kellar, Chief Counsel; R. B. Fleeger, Chief Surgeon; A. J. M. Ross, Mine Superintendent; J. D. Johnson, Chief Engineer; Sidney J. Staple, Mechanical Engineer; J. F. Wiggert, Chief Electrical Engineer, and D. H. McLaughlin, Consulting Geologist. *Incorporated:* November 5, 1877, in California. Annual meeting in main office, third Tuesday in March. *Capital Stock:* 25,116,000 shares of \$100 par value. Listed on the New York Stock Exchange since 1879. Transfer Agent, Irving Trust Company, 1 Wall Street, New York City. *Property:* 602 mining claims aggregating 3,920 acres; 4,674

acres of land held for water rights; 13,761 acres of timber land in South Dakota and 26,004 acres of timber land in Wyoming. *Type of Deposit:* The ore occurs in a layer of cummingtonite-bearing schist of pre-Cambrian age, called the Homestake formation, which is traceable for many miles. The orebodies lie along a group of minor folds forming a large complex anticline. Each orebody follows its own specific fold, and all,—except the Caledonia orebody,—dip steeply to the northeast and plunge at about 35 or 40 degrees to the southeast with the prevailing structure. *Ore:* Gold, containing a little Silver. The Homestake Mining Company also mines coal in Wyoming. Tungsten ore has been mined by the Homestake Mining Company, but from different ore deposits. See Tungsten Bulletin. *Development:* Three vertical shafts are at present in use at the Homestake Mine. These are the B. & M. No. 2 Shaft, the Ellison shaft and the new Ross shaft. Mining operations are now conducted on 25 different levels from the 600-foot level to the 4,100-foot level. *Mining:* The mine is divided into pillars and chambers which are mined by different methods. The chambers are mined by shrinkage stoping, leaving 25-foot crowns. After the ore has been completely drawn from the shrinkage stopes, they are filled. The pillars and crowns are mined by the square-set method, and the square-sets are filled. *Mine Plant:* The Compressor plant comprises 4 two-stage compressors supplying air for rock drills, and 2 four-stage compressors supplying air for haulage. 25 compressed air locomotives of 3½ to 14 tons. 2 storage battery locomotives. 85 automobile trucks, tractors, and cars. Side-dump and end-dump cars of 20 cu. ft. capacity. About 500 rock drills. Two cylindrical-drum electric hoists at Ellison shaft, two bicylindro-conical-drum electric hoists at Ross shaft, and steam hoists in reserve at B. & M. shaft. Two electrical centrifugal ventilating fans on surface, and supplementary fans underground. Electric centrifugal pumps. Electric lighting and signalling. Battery miners lamps and charging equipment. Drill sharpening shop, machine shops, blacksmith shop, foundry and pattern shop. Office, change rooms, tele-

phone exchange, mine rescue and first aid equipment and rooms. *Mills:* Four mills are at present in operation,—the South Mill, of 180 stamps, Cyanide Plants No. 1 and No. 3, and the Deadwood Slime Plant. These mills have a capacity of about 4,000 tons per day. *Power:* Power for the mine and mills is supplied by hydro-electric plants at Spearfish and Englewood, and the new steam-electric plant at Kirk. *Men Employed:* Over 2,000. *Production:* During the year 1935, 1,379,163 tons of ore were milled, realizing an average of \$13.91497 per ton; the bullion reduced being \$19,191,013.19.



Black Hills Studios, Inc., Lead

Figure 23. The Homestake South Mill and Cyanide Plants at Lead

The total bullion production of the Homestake Mine to December 31, 1935, was \$301,019,015.00. *Dividends:* During 1935, \$14,064,960 was paid in dividends. The total dividends paid to December 31, 1935, were \$88,020,442.00 *Ore Reserves:* On December 31, 1935, there were 14,918,132 tons of ore reserves, including 205,441 tons of broken ore in the stopes. At the present rate of milling this would last about 11 years.

HOODOO GROUP: Formerly a part of the Branch Mint Company. *Location:* 8 miles southeast of Deadwood, in the Bear Butte Mining District. *Local Representative:* George Wolfe, Deadwood, S. Dak. *Officers:* Daniel Hill, Presi-

dent; Nathan Hill, Secretary, Lincoln, Nebraska. *Property*: Approximately 120 acres patented. *Type of Deposit*: Porphyry ore and replacement in Deadwood formation. *Ore*: Gold and some Silver. *Development*: 3 shafts 500', 700' and 450' in depth, drifts connecting these three shafts. *Remarks*: Idle since 1912; most of the mining and milling equipment has been salvaged.

HOOSIER MINING AND MILLING COMPANY: Formerly Hidden Treasure Gold Mining and Milling Company. *Location*: 4 miles west of Deadwood in the Whitewood Mining district. *Local Representative*: Banks Stewart, Deadwood, S. Dak. *Officers*: E. A. Trimble, President; W. W. Wittcamper, Secretary. *Incorporated*: South Dakota, 1932. *Capital Stock*: 500,000 shares of \$1.00 par value, none issued. *Property*: 21 patented claims, approximately 194 acres. *Type of Deposit*: Verticals and replacements in porphyry, formerly produced from cement ores. *Ore*: Gold and Silver, Lead, Fluorite. *Development*: 280' shaft with crosscuts. *Mine Plant*: Hoist, 50 HP; Compressor; sinking pump. *Remarks*: Idle since 1916.

HORSESHOE MINING CO.: See Mogul Mining Property.

I. H. DAVIS MINE: *Location*: In Spruce Gulch. *Ownership*: I. H. Davis. *Type of Deposit*: Replacement. *Ore*: Manganese, Gold and Silver. *Remarks*: One carload of ore shipped in 1918 to smelter, but because of lack of market for manganese, was smelted for gold-silver content.

IOWA CLAIM: *Location*: Near Lead. *Ownership*: Homestake Mining Company. *Ore*: Tungsten and Gold. *Reference*: (16).

IRON CLAIM: See Black Hills Tin Company.

IRONSIDES MINING PROPERTY: *Location*: Lawrence County. *Ore*: Gold and Silver.

JOHNSON PROPERTY: See Winner Mining Co.

KATY-DID: See New Discovery.

KEYSTONE MINES: See Goldstone Mining Company.

KICKING HORSE GROUP: *Location:* Blacktail Gulch, 3 miles northwest of Deadwood. *Ownership:* Christian Godfrey, Central City, S. Dak. *Property:* 44 acres of patented ground. *Type of Deposit:* Cement ore. *Ore:* Gold and some Silver. *Development:* 160' shaft with levels at that depth. *Mine Plant:* Hoist, compressor and pumps. *Mill:* Crusher plant having a daily capacity of 100 tons. *Power:* Electrical. *Production:* To 1916—amounted to \$100,000. *Remarks:* Idle at the present time.

KIEMER GOLD MINING AND MILLING CO.: See Fre-
richs Mining Corporation.

LAUREL GROUP: *Location:* In Lawrence County. *Ore:* Gold. *Remarks:* Letter returned unclaimed from former address of owner. *Reference:* (10).

LIGHTNING AND NIAGARA GROUPS: *Location:* In Grizzly Gulch. *Ore:* Gold and some Silver.

LINEAL LODES: See Beaver Creek Mine.

LITTLE JOHNNY CLAIMS: *Location:* 15 miles southwest of Spearfish, S. Dak., in the Rawlins Mining District. *Ownership:* Mr. U. M. Holly, Spearfish, S. Dak., Mr. R. L. Mc Knight, St. Paul, Minn., and George Trott, Minneapolis, Minn. *Property:* 4 unpatented claims, approximately 50 acres. *Type of Deposit:* Replacement in Deadwood formation. *Ore:* Gold and some Silver. *Development:* One 60-ft. tunnel. *Remarks:* Assessment work only.

LITTLE PITTSBURG: *Location:* On Yellow Creek near Wasp No. 2. *Ore:* Tungsten *Reference:* (16).

MAINE AND GOLDEN RULE GROUP: See Wiswell Property.

MAITLAND PROPERTY: See Canyon Corporation.



Figure 24. Mascot Mine in Two Bit Gulch

MASCOT MINE: Formerly the Deadwood-Heidelberg Mine.

Ownership: Mascot Mining Company. *Location:* In the Two Bit Mining District, 6 miles by road east of Deadwood, *Local Representative and Secretary:* Wm. A. Remer, Deadwood, S. Dak. *President:* John Treber, Deadwood, S. Dak. *Incorporated:* South Dakota, April 16, 1929. *Capital Stock:* 500,000 shares having a par value of \$1.00; 88,160 shares issued. *Property:* 9 unpatented claims, approximately 185 acres. *Type of Deposit:* Replacement in Cambrian sediments, shoots of refractory silicious ore. *Ore:* Gold and some Silver. *Development:* 1 shaft 85' in depth, 860' of drifting and crosscutting, also several open cuts. *Production:* 1914-15, 143½ tons returned \$19.30 per ton. *Remarks:* Idle since 1924. Examined 1936.

MOGUL MINING PROPERTY: Formerly the Horseshoe

Mining Company and Mogul Mining Company. *Owner:* B. J. Scanull, Omaha, Nebraska, % First Nat'l Bank. *Local Representative:* Mr. Frank Allen, Deadwood, S. Dak., % Masonic Temple. *Location:* In the Ida Gray Mining District, 2 miles west of Lead. *Property:* 950 acres patented. *Type of Deposit:* Replacement in Cambrian sediments. *Ore:* Gold and some Silver...*Development:* Chiefly by tunneling. *Production:* 1900-1912—\$5,000,000. *Remarks:* Idle since 1914.

MONARCH MINE: See Black Hills Mining Corporation.



Figure 25. The Montana Mine near Rochford

MONTANA MINE: *Location:* 3 miles northwest of Rochford, in an unorganized mining district. *Ownership:* W. J. Brown, Rochford, S. Dak., under option to R. A. Vallier and associates, Deadwood, S. Dak. *Property:* 11 patented claims, approximately 193.82 acres. *Type of Deposit:* Quartz-cum-mingtonite-schist. *Ore:* Gold and some Silver. *Develop-*

ment: A caved tunnel, 110-ft. shaft, 495-ft. tunnel, 444 ft. of drifts and crosscuts. *Remarks:* Cleaning out old workings; 4 men employed.

MONTEZUMA AND THE WHIZZERS: *Location:* Adjoins the city limits of Deadwood on the south and west. *Ownership:* The John T. Milliken estate, National Bank of Commerce, St. Louis, Missouri. *Property:* 150 acres. *Type of Deposit:* Replacement in Cambrian sediments showing schists and slates which carry values. *Ore:* Gold, Silver, Pyrite and Copper. *Development:* By tunneling and crosscutting, the longest tunnel being 650 feet. *Remarks:* Idle at present.

MOORE'S MOLYBDENUM PROSPECT: *Location:* 6½ miles southwesterly from Deadwood on upper part of SE fork of False Bottom Creek. *Ownership:* Wm. Moore, 819 Main St., Deadwood, S. Dak. *Property:* Large acreage known as "Multiply Lode". *Type of Deposit:* Shear zone in porphyry, shale and schist. *Ore:* Molybdenite and Molybdate. *Remarks:* A prospect.

NATIONAL GOLD MINING COMPANY: Formerly the Cutting Mining Company, and Gladiator. *Location:* Adjoins Homestake on the west about one mile from Central City. *Local Representative:* Francis J. Parker, Deadwood, S. Dak. *Officers:* John R. Russell, Deadwood, S. Dak., President; Arthur Hesse, Sr., Deadwood, S. Dak., Vice-President; Francis J. Parker, Deadwood, S. Dak., Secretary. *Other Officers:* C. J. Tolonen and John Kelfstad, both of Duluth, Minnesota, who, together with the officers, constitute the Board of Directors. *Type of Deposit:* Porphyry gold ore. *Ore:* Gold and some Silver. *Development:* 500' two-compartment shaft and several tunnels. *Power:* Electric. *Mine Plant:* Hoist, Ingersoll-Rand compressor. *Mill:* 50-ton mill erected in 1924, consisting of crusher, Marcy ball mills, Overstrum tables, Dorr classifier, and Brown flotation units. *Remarks:* Employed 30 men when in operation. Development work in 1921-22-23-24. *Production:* 1925. Idle since 1925.

NEW DEAL MINING CO.: *Location:* 5 miles northeast of Rochford. *Remarks:* Built a 10-stamp mill in 1934, and made a daily average of six tons for 45 days during the year 1935. *References:* (20) (21).

NEW DISCOVERY: Formerly the Katy-did. *Ownership:* Mr. Martin Brosnahan, Deadwood, S. Dak. *Location:* 7 miles from Deadwood in the Whitewood Mining District. *Property:* 4 unpatented claims, approximately 80 acres. *Type of Deposit:* Replacement in schist. *Ore:* Gold and some Silver. *Development:* Prospect, assessment work only.

NEW IRON HILL: *Location:* 8 miles from Central City in Carbonate Mining District. *Ownership:* New Iron Hill Mining Company. *Local Representative:* Mr. George F. Baggaley, Deadwood, S. Dak., Secretary. *Incorporated:* South Dakota, about 1900. *Capital Stock:* 250,000 shares. *Par value:* \$1.00. *Stock Issued:* 250,000 shares. Charter has expired. *Ore:* Gold and some Silver. *Development:* Old workings not accessible, said to be quite extensive.

NEW RELIANCE MINING COMPANY: See Annie Creek Mining Company.

NIGGER HILL DISTRICT: *Location:* In the vicinity of Tinton. *Ore:* Tin, Tungsten, and Gold. *References:* (15) (16).

NORTH HOMESTAKE CO.: See Canyon Corporation.

ORO FINO: See Gilt Edge Mines, Inc.

PENNSYLVANIA MINE: *Location:* 4 miles westerly from Deadwood in the Whitewood Mining district, near the Cutting and Hoosier Mines. *Property:* 18 patented claims, approximately 245.6 acres. *Representative:* E. P. Trott, Winchester, Mass. *Type of Deposit:* Said to be in slate and schist under a porphyry cap. *Ore:* Gold and some Silver. *Development:* 160' shaft and 867' of drifts, crosscuts and raises. *Remarks:* Company formation now in progress.

PENOBSCOT MINING COMPANY: See Canyon Corporation.

PETTIGREW STUCCO CO.: *Location:* 4 miles north of Spearfish. *Ownership:* Pettigrew estate. *Type of Deposit:* Flat beds interbedded in the Spearfish "Red Beds". *Valuable Mineral:* Gypsum. *Development:* Open pit. *Treatment Plant:* One 1-ton kettle. *Remarks:* Operated 1898—1912. Now idle

PHOENIX GOLD MINING COMPANY: Operated the Dead-Broke Mine, which see.

PORTLAND MINING COMPANY: See Bald Mountain Mining Company.

POTATO GULCH: *Location:* In the Tinton District. *Ore:* Gold, Tin and Tungsten. *References:* (15) (16).

RAINBOW CLAIM: *Location:* 4½ miles south of Whitewood, in the Deadwood Gulch Mining District. *Ownership:* Mr. Nels Thompson, Deadwood, S. Dak. *Property:* Approximately 20 acres of placer ground, patented. *Type of Deposit:* Bar placer. *Ore:* Gold. *Development:* Drift and sluice systems employed, one of the two outfits working. *Production:* One man working during 1935 recovered gold valued at \$400. *Remarks:* 5 men working on percentage basis.

RATTLESNAKE JACK: See Gilt Edge Mines, Inc.

REDDY CLAIM: *Location:* Near Lead. *Ownership:* Homestake Mining Company. *Ore:* Tungsten and Gold. *Reference:* (16).

REPUBLIC MINE: *Location:* 3 miles northwest of Deadwood. *Ownership:* Republic Mining Company, Deadwood, S. Dak. *Property:* 190 acres in Blacktail Gulch near Maitland. *Ore:* Gold and some Silver. *Development:* By drift tunnels. *Remarks:* Idle at present time.

RICHMOND-SITTING BULL MINE: See Double Rainbow.

ROUGH AND READY CLAIM: Principal claim of the Black Hills Tin Co., which see.

SEIM MINE: *Location:* 1 mile from Deadwood adjoining the

Montezuma and the Whizzers on the north. *Ownership:* Olaf Seim, Deadwood, S. Dak. *Type of Deposit:* Replacement in Cambrian sediment. *Ore:* Pyrite. *Production:* 1918—916 tons valued at \$7,200. Total Production to 1925—1,150 tons. *Remarks:* Idle at present time.



Figure 26. The Two Bit Mine of S. R. Smith group

S. R. SMITH GROUP: Formerly the Two Bit Group. *Location:* 6 miles by road southeast of Deadwood in the White-wood mining district. *Representative:* Ross R. Myers, 3527 N. E. 81st Avenue, Portland, Ore. *Property:* 11 patented claims aggregating 114.3 acres. *Type of Deposit:* Veins in Deadwood formation and replacements in the lower dolomite member. *Ore:* Tungsten and Silver. *Development:* By several shallow shafts and two tunnels. *Production:* 1,600 lbs. of tungsten ore in 1916, recorded; a like amount said to have been produced but not recorded. Some silver said to have come from the Yellow Jacket claim. *Remarks:* Examination, 1936.

ST. JOHN CLAIM: *Location:* Near Lead. *Ownership:* Homestake Mining Co. *Ore:* Gold and Tungsten. *Reference:* (16).

TINTON CLAIM: See Black Hills Tin Company.

TINTON REDUCTION CO.: See Black Hills Tin Company.

TINTON TIN MINING CO.: See Black Hills Tin Company.

TROJAN MINING CO.: See Bald Mountain Mining Company.

TWO BIT GROUP: See S. R. Smith Group.

TWO STRIKE MINE: *Location:* On Yellow Creek near Wasp No. 2. *Ore:* Tungsten. *Reference:* (16).

WALL STREET: See Ben Hur.

WASP NO. 2: Formerly owned by the Wasp No. 2 Mining Co. *Location:* 1½ miles south of Lead City. *Ownership:* Homestake Mining Co. *Type of Deposit:* Replacement in the Deadwood formation, a greater percentage of the ore being obtained from the basal quartzite member of the Deadwood formation. *Ore:* Tungsten and Gold. *Production:* 1915—\$147,730; 1916—\$97,869; 1917—\$19,461; 1918—Wasp and Bismarck—\$3,832; 1926—Some production.

WHITE TIN AND GOLD MINE: *Location:* 15 miles west of Spearfish in the Rawlins Mining District. *Ownership:* W. O. Fillmore, Spearfish, S. Dak. *Property:* 3 unpatented claims, approximately 50 acres. *Type of Deposit:* Pegmatite and residual placer. *Ore:* Cassiterite, Tantalum, Tungsten and Placer Gold. *Development:* Test pits and open cuts. *Remarks:* Assessment work only. Some stream tin found here. *Production:* 1913—Stream Tin \$660; 1915—Stream Tin \$120; 1916—Stream Tin \$108. *References:* (15) (16).

WINNER MINING COMPANY: Formerly the Abundance Mining Company Property. *Location:* 2½ miles east of Tinton, in the Rawlins Mining District. *Local Representative:* A. J. Johnston, Tinton, S. Dak. *Officers:* John C. Pence, Winner, S. Dak., Secretary-Treasurer; M. F. Viedt, Winner,

S. Dak., President. *Incorporated:* South Dakota, June 20, 1934. *Property:* 10 unpatented claims, approximately 200 acres. *Type of Deposit:* Gold bearing schist and slates and a placer. *Ore:* Gold, Silver, and Tin. *Development:* By numerous shafts and tunnels, the longest being 400'; workings total 4,000' to a maximum depth of 200'. *Remarks:* Idle at the present time.

WISWELL PROPERTY: Formerly the Maine and the Golden Rule. *Location:* In the Whitewood Mining District, 7 miles southeast of Deadwood. *Ownership:* Mr. Chas. Wiswell, Deadwood, S. Dak. *Property:* 4 unpatented claims, approximately 50 acres. *Type of Deposit:* Replacement in Cambrian sediments and porphyry ore. *Ore:* Gold and some Silver. *Development:* 750' of tunneling. *Mine Plant:* Pump equipment, a single-drum geared hoist; 700' of 12-lb. rail; one 1-ton car. *Power:* Cleveland truck engine. *Remarks:* Working intermittently, employing 5 men doing exploration work, during 1935.

Lyman County

CARPENTER MANGANESE PROPERTY: *Location:* Near Oacoma, S. Dak. *Ownership:* Mr. E. S. Carpenter, 602 Bankers Trust Bldg., Des Moines, Iowa. *Property:* Approximately 3,000 acres. *Type of Deposit:* Shale beds containing nodules of manganiferous iron. *Ore:* Low grade manganese. *Remarks:* No activity at the present time.

GENERAL MANGANESE CORPORATION: *Location:* In the vicinity of Oacoma and Chamberlain, S. Dak. *Officers:* K. M. Leute, 450 Baker Bldg., Minneapolis, Minnesota, President; Mr. Norton J. Miller, Detroit, Michigan, Sec.-Treas.; Mr. M. Q. Sharpe, Kennebec, S. Dak., Fiscal Agent. *Capital Stock:* 500,000 shares of no par value, with 218,193 shares outstanding. *Property:* Own approximately 12,000 acres and lease approximately 100,000 acres, a part of this property in Brule County. *Type of Deposit:* Shale beds containing manganiferous iron nodules. *Ore:* Low grade manganese. *Remarks:* A large amount of money has been

spent for land purchases, lease payments, and geological and analytical work. Inactive at present.

SHARPE MANGANESE PROPERTY: *Location:* Near Oacoma, S. Dak. *Ownership:* Mr. M. Q. Sharpe, Kennebec, S. Dak. *Property:* Approximately 2,000 acres. *Type of Deposit:* Shale beds containing nodules of manganiferous iron. *Ore:* Low grade manganese. *Remarks:* Idle at present time.

Meade County

DAKOTA PLASTER COMPANY: *Location:* At Black Hawk. *Ownership:* U. S. Gypsum Co., Chicago, Ill. *Property:* 240 acres in unorganized mining district. *Type of Deposit:* Flat deposits interbedded in Spearfish "Red Beds". *Valuable Mineral:* Gypsum. *Development:* Open pit and room and pillar underground mine. *Mine Plant:* Electric auger-type drill, quarry cars, hoist, wheel scrapers and disc plow. *Treatment Plant:* One jaw crusher, one rotary pot crusher, one Raymond mill, two 10-ton kettles, 10 conveyors, two elevators, one 5-bag sacker, one block machine, one fibre machine and electric motors. *Power:* Electric from lines of the Dakota Power Co. *Remarks:* Idle and plant being dismantled.

HOMESTAKE MINING CO., LIMESTONE QUARRY: *Location:* At Calcite, 4½ miles northwest of Piedmont. *Ownership:* Homestake Mining Co., Lead, S. Dak. See Lawrence County. *Type of Deposit:* Flat bed with some red shale overburden. *Valuable Material:* Minnekahta limestone. *Development:* Side hill quarry. *Treatment Plant:* Two shaft-kilns. *Production:* 1904-1930, about 70,000 tons of lime. *Remarks:* Plant idle at present.

JOHN SAWYER PLANT: *Location:* 2 miles west of Crystal Cave. *Type of Deposit:* Flat bed. *Valuable Material:* Pahasapa limestone. *Remarks:* Operated about 1893 to 1900. Kiln now destroyed.

ORTH COAL PROPERTY: *Location:* Near Stoneville. *Ownership:* Henry Orth, Stoneville, S. Dak. *Type of Deposit:*

Flat-lying beds. *Valuable Mineral*: Lignite coal. *Remarks*: Abandoned 1929.

OVERLAND COAL PROPERTY: *Location*: Near Stoneville. *Ownership*: Guy Overland, Stoneville, S. Dak. *Type of Deposit*: Flat-lying beds. *Valuable Mineral*: Lignite coal.

SCHUSTER COAL PROPERTY: *Location*: Near Stoneville. *Ownership*: Joe Schuster, Stoneville, S. Dak. *Type of Deposit*: Flat-lying beds. *Valuable Mineral*: Lignite coal. *Remarks*: Letters returned unclaimed.



Figure 27. Plant of the United States Gypsum Company at Piedmont

U. S. GYPSUM COMPANY: *Location*: $\frac{1}{2}$ mile north of Piedmont. *Ownership*: U. S. Gypsum Co. *Property*: Plant and mine in unorganized mining district. *Type of Deposit*: Flat beds interbedded with red shales. *Valuable Material*: Gypsum. *Mining*: By open pit and room and pillar. *Mine Plant*: One electric drill, eight quarry cars, two electric hoists, wheel scrapers and disc plows. *Treatment Plant*: One crusher, one dryer, one roller mill, one calcining kettle, one mixer and a 5-bag sacker, conveyors and electric motors. *Power*: Electric from Dakota Power Co. *Remarks*: Operates intermittently.

W. V. DOYLE PLANT: *Location:* At Doyle, 2 miles east of Crystal Cave. *Type of Deposit:* Flat bed. *Valuable Material:* Pahasapa limestone. *Remarks:* Operated about 1895 to 1904. Kiln now destroyed.

YEAMAN COAL PROPERTY: *Location:* 2 miles from Stoneville. *Ownership:* Harry E. Yeaman, Stoneville, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal. *Development:* By shaft, drifts and crosscuts. *Mine Plant:* Whim hoist, 5-ton bin. *Remarks:* 3 tons per day mined; 3 men employed by contract for $\frac{1}{2}$ of output. Annual output 600 tons.

Minnehaha County

CONSOLIDATED SAND AND STONE CO.: *Location:* Offices at Sioux Falls, S. Dak. Sand and gravel pit at Wheeler Spur, 4 miles northeast of Sioux Falls. For stone quarry, and other particulars, see under Hanson County. *Property:* Plant is located on leased land. *Type of Deposit:* Sand and gravel bed. *Valuable Material:* Sand and gravel. *Plant:* Sand and gravel washing plant with annual capacity of 50,000 tons. *Production:* 500,000 tons of sand and gravel to date. *Remarks:* Operating at present.

DAKOTA GRANITE CO.: *Location:* Sioux Falls. *Ownership:* Dakota Granite Co. *Superintendent:* A. T. Cronk, 132 N. Prairie Ave., Sioux Falls, S. Dak. *Valuable Material:* Sioux Quartzite (Sioux Falls Granite.) *Annual Production:* 50,000 tons. *Mine Plant:* Power shovel, churn drills, electric hoist. *Mill:* Disc crusher and rotary screens. *Remarks:* Recent letter returned unclaimed. *Reference:* (18).

DELL RAPIDS QUARRY CO.: *Location:* Dell Rapids. *Ownership:* Dell Rapids Quarry Co. *Head Office:* 111 West Washington, Chicago, Illinois. *Incorporated:* S. Dak., 1912. *Capital Stock:* 1,000 shares, \$100 par value; 193 shares issued. *Officers:* George Mason, Chicago, Ill., President; William Armstrong, Manager; Charles J. Trainor, Dell Rapids, S. Dak., Superintendent. *Valuable Material:* Sioux



Figure 28. The Quartzite Quarry of the Dell Rapids Quarry Company

Quartzite. *Production*: 1920—35, 440,000 tons. *Mine Plant*: Power shovel, well drill and cars. *Mill*: Jaw crusher and screens. *Remarks*: Operating at present, employing 30 men. *Reference*: (18).

L. G. EVERIST, INC.: *Location*: Dell Rapids, S. Dak. *Ownership*: L. G. Everist, Inc. *Incorporated*: Iowa, 1914. *Capital Stock*: 1,000 shares, \$100 par value, 931 shares issued. *Officers*: L. G. Everist, Sioux City, Iowa, President; Hubert Everist, Manager. *Valuable Material*: Sioux Quartzite. *Annual Production*: 50,000 tons. *Mine Plant*: Power shovel. *Mill*: Gyratory crusher and screens. *Remarks*: Operating at present. *Reference*: (18).

LOWE AND HANDLEY: See W. V. Lowe Granite Co.

WISCONSIN GRANITE CO.: *Location*: Sioux Falls. *Head Office*: 105 West Monroe Street, Chicago, Ill. *Officers*: W. S. Primley, Chicago, President; J. A. McQuire, Vice President. *Valuable Material*: Sioux Quartzite. *Annual Production*: 25,000 tons. *Mine Plant*: Armstrong drills. *Mill*: Jaw crusher. *Reference*: (18). *Remarks*: Letter sent to this company 1936 returned marked "Out of business."



Figure 29. Quarry of the W. V. Lowe Granite Company of East Sioux Falls

W. V. LOWE GRANITE CO.: Formerly Lowe and Handley. *Location:* East Sioux Falls and Rowena. *Ownership:* W. V. Lowe, Sioux Falls, S. Dak. *Property:* 4 quarries in East Sioux Falls. *Type of Deposit:* Pre-Cambrian Quartzite. *Valuable Material:* Sioux Quartzite (manufactured into building stone, paving blocks and concrete aggregate). *Remarks:* Not operating. *Reference:* (18).

Pennington County

ABERDEEN MINING CO.: See Coats J. R. Group.

ADDIE MINE: *Ore:* Tungsten. *Reference:* (3).

ALDEN & BONNIE PLACER CLAIM: *Location:* 7½ miles north of Hill City, near Redfern, in unorganized mining district. *Ownership:* Mr. O. A. Schwartz, Hill City, S. Dak. and Frank Heisler, Sturgis, S. Dak. *Property:* 2 unpatented claims, approximately 40 acres. *Type of Deposit:* Gulch placer. *Ore:* Gold. *Development:* Several small open cuts. *Remarks:* Assessment work only.

ALICE CLAIM: *Location:* Near Keystone. *Type of Deposit:* Pegmatite. *Valuable Mineral:* Lithium. *Reference:* (13).

AMERICAN RUSHMORE MINING CO.: *Location:* At Keystone. *Incorporated:* South Dakota. *Capital Stock:* 3,000,000 shares. *Par Value:* \$1.00. *Officers:* J. Wray Sharp, Rapid City, President; H. H. Randolph, Rapid City, S. Dak., Secretary; Charles C. Wells, Chicago, Ill., Vice President; A. I. Johnson, Keystone, S. Dak., Superintendent. Charles C. Cooper, Chicago, Illinois, and Bancroft Gore, Rapid City, comprise the other directors. *Property:* 7 and a fraction claims comprising 65 acres held under option to buy. Gold Dust Group, Big Hit Group, and Sitting Bull No. 1 and Sitting Bull, which see. *Type of Deposit:* Lenticular quartz bodies lying along bedding planes of a series of well-defined shear zones in pre-Cambrian schist. *Ore:* Gold and some silver. *Development:* Considerable amount of tunneling on Bullion and Columbia Mines. *Remarks:* Some recent development work done.

AMERICAN TIN AND TUNGSTEN COMPANY: See National American Tin Corporation.

AMERICAN TUNGSTEN MINING COMPANY: See Good Luck Property.

ANNIE CLAIM: A part of Mohawk Group—owned by National American Tin Corp. *Location:* $\frac{1}{2}$ mile west of Hill City. Formerly owned by Mills Bros. *Ore:* Tin and tungsten. *References:* (15) (16).

ANTLER MINE: See Central Black Hills Gold Mine.

ASHLEY AND NYSWANGER CLAIM: *Location:* In the vicinity of Placerville, 2 miles from Pactola in an unorganized mining district. *Ownership:* Charles Ashley, Rapid City, S. D., R.F.D. No.1 and Lydia Nyswanger, 626 Quincy St., Rapid City, S. Dak. *Property:* 4 unpatented claims, approximately 80 acres in area. *Type of Deposit:* Shear zone. *Ore:* Gold, Silver, and a little Copper and Galena. *Development:* Small open pits and trenches. *Remarks:* Assessment work only.

BARNES LODGE: Formerly the Black Tom Mine. *Location:* 4½ miles Southeast of Mystic. Unorganized mining district. *Ownership:* Mr. Ray M. Clark, Mystic, S. Dak. *Property:* 3 unpatented claims aggregating approximately 60 acres. *Type of Deposit:* Shear zone. *Ore:* Gold and some Silver. *Development:* 80' shaft, 150' of tunneling. *Remarks:* Idle since 1908.

BATTLE AXE MINE: See Sunflower.

BATTLE CREEK: *Location:* In the southern Black Hills. *Ore:* Tin. *Reference:* (15).

BEACHER AND LAPPING GROUP: Formerly Black Diamond Group. *Location:* 4½ miles west of Keystone, unorganized mining district. *Ownership:* Mr. George R. Hardesty, Keystone, S. Dak. *Property:* 5 unpatented claims approximately 60 acres. *Type of Deposit:* Fissure vein. *Ore:* Gold and some Silver. *Development:* 120' of tunneling. Several 10' x 12' holes for assessment work. *Remarks:* A prospect.

BESSIE B. LODGE: *Location:* In an unorganized mining district, ½ mile north of Mystic. *Ownership:* Mr. Ellis Barker, Rochford, S. Dak. *Property:* 6 unpatented claims, approximately 120 acres. *Type of Deposit:* Shear zone. *Ore:* Gold and some Silver. *Development:* 3 shafts, 40', 50', and 30' in depth, 700' of tunneling, 50' of drifting and cross-cutting. Also several open cuts on the vein. *Remarks:* An option has been let on the property and incorporation papers have been filed by the company.

BISMARCK AND IDA FLORENCE GROUP: *Location:* 1 mile N. W. of Keystone, S. Dak. *Ownership:* Under lease and option to the Mines Finance and Development Shares, Inc. (Which see). *Property:* Approximately 95 acres patented. *Type of Deposit:* Quartz stringers in pre-Cambrian schist. *Ore:* Gold, Arsenic and some Silver. *Development:* By two shafts 315' and 435' in depth, also 15,000' of lateral workings. *Mine Plant:* Hoist, air compressor, boiler and engine; also powerhouse and blacksmith shop recently

built. *Remarks:* Employing approximately 10 men since July 1, 1936 unwatering and retimbering 435' shaft, sampling and preparing to develop orebody. Application made for R.F.C. loan.

BLACK BIRD CLAIM: Formerly owned by Canfield, Hicks, and Roush. *Location:* $4\frac{1}{2}$ miles southeast of Hill City in an unorganized district. *Property:* 1 unpatented claim, approximately 20 acres. *Type of Deposit:* Quartz vein in pre-Cambrian schist. *Ore:* Tungsten. *Development:* By trenching for a distance of 75' along the strike of the vein; a vertical shaft approximately 40' in depth, which is inaccessible. *Remarks:* The vein is not well exposed and its size and extent are unknown. This is a prospect only. *Reference:* (16).

BLACK CRYSTAL: *Location:* 5 miles northeast of Hill City, unorganized mining district. *Ownership:* G. H. Hardesty and Bert Hardesty, Keystone, S. Dak. *Property:* 1 unpatented claim, approximately 20 acres. *Type of Deposit:* Quartz vein in pre-Cambrian slate and schist. *Ore:* Tungsten (Wolframite). *Development:* A 60' shaft and some drifting and crosscutting; a prospect cut along the strike of the vein for a distance of about 30' and at a depth of 7' below the surface. *Remarks:* No work done here since 1916. *Production:* 1915—\$425.

BLACK DIAMOND CLAIM: *Location:* $7\frac{1}{2}$ miles southwest of Hill City. *Ownership:* Bert Robinson, John Foster and George Grant, Custer, S. Dak. *Property:* 1 unpatented claim approximately 20 acres. *Type of Deposit:* Quartz vein in pre-Cambrian schist. *Ore:* Tungsten (Wolframite). *Development:* The vein has been opened for a distance of 150' along the strike by prospect trenches and test pits, maximum depth of which is 15'. *Remarks:* This is a prospect. *Reference:* (16).

BLACK DIAMOND GROUP: See Beacher and Lapping Group.

BLACK HILLS COPPER COMPANY: *Location:* In the Rochford Mining District, 6 miles northwest of Rochford. *Local Representative:* Olaf Soholt, Deerfield, S. Dak.

Secretary: George M. Thrasher, Benton Harbor, Mich. *Incorporated:* South Dakota. *Capital Stock:* 1,000,000 shares. *Par Value:* \$1.00. *Stock Issued:* 500,000 shares. *Property:* 25 claims, 60 acres patented, remainder unpatented. *Type of Deposit:* Fissure vein and replacement in carbonate rock. *Ore:* Copper, Silver, and Gold. *Development:* An 800' shaft, 595' of crosscutting. *Remarks:* Assessment work only. Idle since 1901.

BLACK HILLS GYPSUM CO.: *Location:* Near Rapid City. *Ownership:* U. S. Gypsum Co., *Ore:* Gypsum. *Remarks:* Completely dismantled. Operated 1907-1915. Plant burned and was not rebuilt.

BLACK HILLS KEYSTONE CORP.: *Location:* In ~~Key~~^{Keystone} district near Keystone. *Officers:* W. K. Wallace, 530 Fifth Avenue, New York, President and secretary; A. I. Johnson, Resident Manager. *Incorporated:* In South Dakota. *Property:* Bob Ingersoll, Sitting Bull, pegmatites; Coon Hollow Group, Holy Smoke Group, Lottie and Leota, gold properties. *Type of Deposit:* Pegmatite and quartz veins. *Valuable Minerals:* Pegmatite minerals, Gold and some Silver.



Figure 30. Crushing Plant of the Black Hills Marble Quarries Corp. near Rapid City

BLACK HILLS MARBLE QUARRIES: *Location:* In unorganized mining district, 3½ miles northwest of Rapid City. *Ownership:* Black Hills Marble Quarries Corp. *Officers:* C. W. Erickson, President; A. M. Lanphere, Rapid City, S. Dak., Secretary and Local Representative. *Incorporated:* South Dakota, 1927. *Property:* 580 acres patented ground. (Includes Black Hills Marble Quarry No. 1 and No. 2). *Type of Deposit:* Flat bed overlain with red shale. *Valuable Material:* Minnekahta limestone. *Development:* Open pit stepped-face quarry. *Mine Plant:* One Jackhammer, two steel side-dump quarry cars and other necessary light quarry tools. *Treatment Plants:* 300-ton crushing plant at one quarry; and lime plant at other quarry, with three 8-ft. kilns, one rotary crusher, one hydrator, one 3½ ft. air separator, and one 2-bag sacker. *Power:* Electric power from Dakota Power Co. Gas from Mont.-Dak. Power Co. *Production:* Annual production about 2,400 tons. *Remarks:* Operating and employing 5 men, producing crushed rock.

BLACK HILLS TUNGSTEN COMPANY: See Heart of the Black Hills Property.

BLACK METAL CLAIMS: *Location:* 1 mile north of Hill City, unorganized mining district *Ownership:* The Wolf Tongue Mining Co., Nederland, Colo. *Property:* 9 patented claims, approximately 180 acres. *Type of Deposit:* Quartz veins in pre-Cambrian slates and mica schist. *Ore:* Tungsten and Tin. *Development:* 60' of trenching and a 47' shaft on No. 3 claim; and a 65' shaft (vertical) and a 60' of drifting at the bottom of the shaft on the No. 6 claim; 2 test pits on No. 5 claim; the development on the other claim consists of trenching and shallow test pits. *Remarks:* This property has been prospected for tin and tungsten. Idle at present time.

BLACK TOM MINE: See Barnes Lode.

BLUE BIRD: Formerly owned by the Harney Peak Tin M. M. & Mfg. Co. *Ore:* Tin. *Reference:* (15).

BLUE TALC: Formerly Cuttysark Mine. *Location:* Unorgan-

ized mining district in the vicinity of Mystic. *Ownership:* Mr. Ellis Barker, Rochford, S. Dak. *Property:* 1 unpatented claim, approximately 20 acres. *Type of Deposit:* Shear zone. *Ore:* Gold and some Silver. *Development:* 4 shafts 30', 50', 20' and 200' depth. *Remarks:* Assessment work only. Idle since 1902. Owner contemplating opening mine and milling high grade ore.

BOB INGERSOLL: *Location:* Unorganized mining district 3 miles west of Keystone. *Ownership:* Black Hills Keystone Corp., which see. *Property:* 3 patented claims, approximately 30 acres. *Type of Deposit:* Pegmatite. *Valuable Minerals:* Lepidolite, Feldspar, Beryl, Amblygonite, Spodumene, Tantalite. *Production:* 312 tons \$14,306.00. *Remarks:* Idle since March 1934.

BULL CON: *Ownership:* Thomas A. Edison Co. Formerly owned by Dave Swanzey. *Location:* 1 mile southeast of Keystone. *Type of Deposit:* Pegmatite. *Ore:* Lithium minerals. *Reference:* (11).

BUCKEYE AND LENA CLAIMS: See Union Hill Mine.

BUTTE CLAIM: *Location:* 7 miles southwest of Hill City. *Type of Deposit:* Pegmatite. *Ore:* Tin. *Reference:* (11).

CALIFORNIA GROUP: See Hopeful Tin Property. *Reference:* (2).

CALUMET, DAKOTA CONTINENTAL COPPER CO.: *Location:* Near Sheridan. Formerly the Contintenal Copper Mining Smelter. *Property:* 52 patented claims, approximately 179 acres. Dakota Calumet and Lillian Mine. *Type of Deposit:* Pyrrhotized zone in quartz and schist. *Ore:* Gold and Pyrrhotite. *Development:* 850' shaft, 1,170' cross-cut tunnel, and 9 drift tunnels. *Mine Plant:* 300 HP steam plant, hoist, 7 drill compressor. *Remarks:* Has been idle for several years.

CAMPAIGN: *Location:* 1/2 mile west of Hill City. *Ore:* Tin. *Reference:* (15).

CARNBRAY TIN MINE: *Location:* 4 miles northeast of Hill City. *Ore:* Tin.

CASSITERITE: *Location:* $\frac{1}{2}$ mile west of Hill City adjoining the Tin Boom Mine on the east. *Ore:* Tin. *Reference:* (15).

CASTLE CREEK PLACER: *Location:* Unorganized mining district in the vicinity of Mystic, leased by Joe P. Welch, Mystic, S. Dak. *Ownership:* Mrs. Mary Ghery, Rapid City, S. Dak. *Type of Deposit:* Bar and creek placer. *Ore:* Gold. *Development:* Twin sluice and dragline system employed. *Remarks:* 6 men setting up dragline and getting ready to operate in 1935.

CELIA: *Location:* Near Keystone. *Valuable Mineral:* Mica. *Reference:* (13).

CENTRAL BLACK HILLS GOLD MINE: Formerly the Antler Gold Mine. *Location:* 3 miles northwest of Hill City, in an unorganized mining district. *Ownership:* Hal Jones, Hill City, S. Dak. *Property:* 2 claims and a millsite, unpatented, approximately 45 acres. *Type of Deposit:* Fault fissures in shear zone. *Ore:* Gold and some Silver. *Development:* 40' shaft, 70' shaft, approximately 220' of lateral workings. *Mine Plant:* Gas power hoist, run by 8 HP Le Roy engine, capacity 1,800 lbs. at 150' per minute. *Remarks:* Now under development

CHAMPION LODE: Formerly owned by Pennington and Smith. *Location:* $4\frac{1}{2}$ miles east of Hill City, unorganized mining district. *Property:* 1 unpatented claim, approximately 20 acres. *Type of Deposit:* Pegmatite 3' to 6' in thickness, wolframite occurring in the quartz and mica. *Ore:* Tungsten. *Development:* The dike is opened up by several cuts to a depth of 20' for a distance of 600' along the strike. *Remarks:* This is a prospect only.

CHARLES BENJAMIN MINE: *Location:* 9 miles northwest of Hill City. *Ownership:* Mr. L. C. Green, Hill City, S. Dak. *Property:* 1 unpatented claim, approximately 20 acres. *Type of Deposit:* Shear zone in pre-Cambrian slates and

schist. *Ore*: Gold and some Silver. *Development*: Several trenches and test pits. *Remarks*: This is a prospect only.

CLARA BELLE MINE: See Golden Arrow Mines.

CLEVELAND LODGE: Formerly owned by American Tungsten Co.; a part of Good Luck Property, which see. *References*: (9) (13).

CLYDESDALE: *Location*: Adjoins Harney Hydraulic near Keystone. *Ownership*: A. I. Johnson, Keystone, S. Dak. *Property*: 1 unpatented claim, approximately 20 acres. *Type of Deposit*: On diorite contact. *Ore*: Gold and some Silver. *Development*: Openings along contact.

COATS CLAIM: Formerly owned by George Coats, Hill City. *Location*: 1 mile southwest of Hill City, in unorganized mining district. *Property*: 1 unpatented claim, approximately 20 acres. *Type of Deposit*: Pegmatite containing small amounts of wolframite and cassiterite. *Ore*: Tungsten and Tin. *Development*: Small open cuts. *Remarks*: This is a prospect. *References*: (9) (13).

COATS J. R. GROUP: Formerly the Aberdeen Mining Company. *Location*: In an unorganized mining district, 4 miles northeast of Hill City. *Ownership*: George Coats, Hill City, S. Dak. *Property*: 5 patented claims, approximately 70 acres and 1 unpatented claim, approximately 15 acres. *Type of Deposit*: Fissure vein. *Ore*: Gold and some Silver. *Development*: 2 shafts 75' in depth. *Remarks*: This is a prospect only.

COBALT: Formerly the Margaret. *Location*: 2 miles east of Keystone. *Ore*: Lithium. *Reference*: (5).

COLLOSSAL CLAIM: *Ore*: Tin. *References*: (2) (15).

CONSOLIDATED FELDSPAR CORP.: Leasing Hugo Mine. *Location*: At Keystone. *Superintendent*: M. Susong, Keystone, S. Dak. *Mill*: An 80-ton Feldspar grinding plant. *Power*: Diesel-electric. *Remarks*: Operating and employing



Figure 31. Feldspar Plant of the Consolidated Feldspar Corporation at Keystone

30 men in the plant and at the mine. Producing approximately 50 cars of ground feldspar per month.

COPPER GLANCE: Formerly the Poisoned Ox and the Uranium Lode. *Location:* In an unorganized mining district, in the vicinity of Pactola. *Ownership:* Mr. P. J. Nepper, Rapid City, S. Dak. *Property:* 12 unpatented claims, approximately 240 acres. *Type of Deposit:* Vein and replacement. *Ore:* Gold, Copper, and some Silver. *Development:* 200' of tunneling. Several open cuts along the vein. Development work now progressing, vein encountered, hoist and building erected. A new tunnel being driven to base of deposit, other open cuts developed. *Remarks:* Assessment work only.

COWBOY TIN MINE: Property of the National American Tin Corp., which see. *Location:* $1\frac{1}{2}$ miles southwest of Hill City in an unorganized mining district. *Property:* 15 patented claims, approximately 158 acres. *Type of Deposit:* Lenticular quartz-mica shoots in Algonkian schist, 1' to 5' in width and up to 130' in length. *Ore:* Tin. *Development:* A

three-compartment shaft, depth 300', inclination approximately 68°, and 2,150' of lateral workings. *Mill*: Formerly used the 250 ton concentration plant which was erected by the Harney Peak M. M. & Mfg. Co., 1 mile east of Hill City, has been dismantled. *Production*: A considerable amount of ore has been stoped between the surface and the 185' level. *Remarks*: Idle since 1921. *Reference*: (15).

CUMBERLAND MINING AND MILLING CO.: See J. R. Mine (Crocker).

CUSTER GROUP: *Location*: 1½ miles east of Hill City, formerly owned by Harney Peak Tin M. M. & Mfg. Co. *Ore*: Tin. *References*: (1), (15).

CUTTYSARK MINE: See Blue Talc.

DAN PATCH CLAIMS: *Location*: Near Keystone. *Type of Deposit*: Pegmatite. *Valuable Mineral*: Beryl. *Reference*: (19).

DARK CANYON STONE CO.: *Location*: Near Rapid City. *Valuable Material*: Crushed rock, sand and stone. *Manager*: F. M. Lockhart. *Mine Plant*: Power shovel. *Mill*: Crusher and screens. *Remarks*: Not operating. *Reference*: (18).

DEACON WRIGHT CLAIM: *Location*: 7 miles southwest of Hill City. Formerly owned by Harney Peak Tin M. M. & Mfg. Co. *Ore*: Tin. *References*: (1), (15).

DEXTER LODGE: Formerly the Yellow Bird Mine. *Location*: In the Rochford Mining District, 4½ miles west of Rochford. *Ownership*: Mr. Ed. Harding, Rochford, S. Dak. *Property*: 1 full claim and a fraction. *Type of Deposit*: Shear zone. *Ore*: Gold and some Silver. *Development*: 2 shallow shafts and several open cuts. *Remarks*: Assessment work only. One shaft on this property is 150' deep with several crosscuts.

DIANA GROUP: *Location*: Adjoins the city limits of Silver City on the west. Unorganized mining district. *Ownership*: John Gorman estate. *Local Representative*: Joe

Burke, Silver City, S. Dak. *Property*: 7 unpatented claims, approximately 70 acres. *Type of Deposit*: Fissure vein. *Ore*: Gold, Lead, Antimony, and some Silver. *Development*: 515' of tunneling. *Remarks*: Assessment work only.

DICTATRUM LODGE NO. 1 AND NO. 2: *Location*: 1 mile north and west of Silver City, in an unorganized mining district. *Ownership*: Ed Tuttle, Silver City, S. Dak. *Property*: 3 patented claims, approximately 60 acres. *Type of Deposit*: Fissure vein. *Ore*: Gold, Lead, Antimony and some Silver. *Development*: 42' shaft and several open cuts. *Remarks*: Idle at present time.

DIVIDE: Formerly the Mercedes. *Location*: 7 miles from Rochford. *Ownership*: Mr. Ed. Harding, Rochford, S. Dak. *Property*: 12 unpatented claims. *Type of Deposit*: Shear zone. *Ore*: Gold and some Silver. *Development*: 140' shaft, 2 short tunnels; several open cuts and test pits. *Remarks*: Assessment work only.

D. O. BECKMAN PROPERTY: Formerly Vierregg and Hagge claims. *Location*: Unorganized mining district 1½ miles north and west of Keystone, adjoining the north end of what was formerly known as the Cross Property. *Ownership*: D. O. Beckman and Hagge Brothers, Grand Island, Nebraska. *Property*: 4 patented claims, approximately 35 acres. *Type of Deposit*: Shear zone. *Ore*: Gold and some Silver. *Development*: 440' of tunneling at the present time. *Remarks*: Owners have a map showing different locations of ore bodies and veins made by A. I. Johnson, Engineer, Keystone, S. Dak.

DOL COAD AND TEA LODGE: *Location*: Unorganized mining district, 4 miles from Hill City. *Ownership*: Harry, Emil, Ed and Clarence Smith. *Property*: 6 patented claims, approximately 58 acres. *Type of Deposit*: Fissure vein. *Ore*: Gold and some Silver. *Development*: 2 shafts, 155' and 80' in depth, 210' of tunneling. *Remarks*: Idle since 1895, except for a small amount of development work during 1935.

DOUBLE STAR: *Location:* 4 miles west of Rochford, in the Rochford Mining District. *Ownership:* Mrs. Johanna Hausle, 1314 Eighth Street, Rapid City, S. Dak. *Property:* 2 unpatented claims, approximately 40 acres. *Type of Deposit:* Flat deposit underlain by a clay bed, and overlain by a shallow layer of loamy soil. *Valuable Mineral:* Bog Iron Ore. *Development:* Large amount of material has been stripped. *Remarks:* Idle since 1935. Last shipment October, 1933.

DUNN, TRUAX AND COMPANY: *Location:* Unorganized mining district in the vicinity of Redfern, S. Dak. *Ownership:* Mr. L. B. Dunn and Mr. R. L. Truax and Annie Truax. *Property:* 3 unpatented claims, approximately 60 acres. *Type of Deposit:* Gulch Placer. *Ore:* Gold. *Development:* Open pits. *Remarks:* Assessment work only.

DYKE CLAIM: *Location:* $\frac{1}{2}$ mile east of Hill City. Formerly owned by the Harney Peak Tin M. M. & Mfg. Co. *Property:* 1 unpatented claim, approximately 20 acres. *Type of Deposit:* Pegmatite dike which contains Tungsten, Quartz, Feldspar, Muscovite, Tourmaline and Graphite. *Ore:* Tungsten. *Development:* Prospect holes and small shaft. *Remarks:* A prospect.

ECLIPSE GROUP: (M. M.; King Cotton; Eclipse Placer: Bessie: Bessie No. 1: Eclipse, Cracker Jack: Bruiser and Maggie). *Location:* $2\frac{1}{2}$ miles south of Keystone on Iron Creek. *Ownership:* M. M. Gerard, Humphrey Estate, Ed Stenger Estate. *Property:* 9 patented claims, approximately 140 acres. *Type of Deposit:* Shear zone in pre-Cambrian slates and schist. *Ore:* Gold, Arsenic and some Silver. *Development:* Numerous shafts and tunnels. *Remarks:* Idle at the present time.

EDNA HAZEL CLAIM: *Location:* $4\frac{1}{2}$ miles northeast of Hill City. *Property:* 1 unpatented claim, approximately 20 acres. *Type of Deposit:* A vein of clear glassy quartz varying from a few inches to 2 feet in width and cutting the pre-Cambrian schist. *Ore:* Tungsten; an analysis by M. L.

Hartman showing the mineral to be composed of 60.7% FeWO_4 and 30.7% MnWO_4 . *Remarks:* Crystals of wolframite $\frac{1}{2}$ " to 2" in length have been found, the vein is said to have been very rich in places; not operating.

EGYPTIAN MINE: *Location:* Near Keystone. *Local Representative:* Pat O'Keefe, Keystone. *Type of Deposit:* Small quartz stringers in pre-Cambrian slates and schist. *Ore:* Gold and some silver. *Remarks:* Made a shipment of ore to Colorado Smelter 1934. Installed some milling equipment in 1935. *Reference:* (20).

ELDORADO: *Location:* 3 miles southeast of Hill City. *Ore:* Tin. *Reference:* (15).

ELKHORN TUNGSTEN CO.: Formerly Black Hills Tungsten Co. See Heart of the Black Hills Property.

EMMA CLAIM: *Location:* In an unorganized mining district, 8 miles east of Hill City. *Ownership:* Mr. George H. Soliday and Bert Hardesty, Keystone, S. Dak. *Property:* 1 unpatented claim, approximately 20 acres. *Type of Deposit:* Fissure vein. *Ore:* Gold and some Silver. *Development:* Developed by tunneling. *Remarks:* Assessment work only.

EMMA MICA MINE: *Location:* Near Keystone. *Reference:* (13).

EMPIRE GOLD MINES, INC.: Formerly Golden Slipper and Forest City Mines. *Location:* Five miles northeast of Hill City, S. Dak. and 23 miles west of Rapid City. *Officers:* President, Ingles M. Uppercu, 620 $\frac{1}{2}$ St. Joe St., Rapid City, and 2 Rector St., New York, N. Y. *Local Representative:* George Flavin, Rapid City, S. Dak. *Incorporated:* In South Dakota. *Capital Stock:* \$1,000,000. *Par Value:* \$1.00 *Property:* About 900 acres of lode and placer claims including Golden Slipper and Forest City Mines. *Type of De-*



Photo by Rise Studio, Rapid City

Figure 32. Golden Slipper Mine of Empire Gold Mines, Inc., near Hill City

posit: Veins in pre-Cambrian slates and schist. *Ore:* Gold and Silver. *Mine Plant:* Drills, hoists, compressors, pumps. *Mill Plant:* 75 ton amalgamation and flotation mill remodeled by Denver Equipment Co. *Remarks:* Operating, employing 35 men.

EQUALITY: *Location:* 2 miles southwest of Keystone. *Ore:* Lithium. *Reference:* (5).

ETTA MINE: Formerly owned by the Harney Peak Tin M. M. & Mfg. Co., and the Standard Essence Co. *Present Owner:* Maywood Chemical Works, Maywood, New Jersey. *Type of Deposit:* Pegmatite. *Valuable Minerals:* Spodumene, Feldspar, Beryl, and other pegmatite minerals. *Remarks:* At present being operated for spodumene.



Figure 33. Etta Mine of the Maywood Chemical Works near Keystone

EVERGREEN CLAIM: *Ore:* Tin. *Reference:* (15).

EVERLY: *Location:* $1\frac{1}{2}$ miles east of Keystone. *Valuable Mineral:* Mica. *Reference:* (11).

EXCELSIOR CLAIM: *Valuable Mineral:* Tin. *Reference:* (15).

FALLS PLACER AND LODGE: Formerly Falls Placer:
Location: 3 miles from Mystic in an unorganized mining district between Mystic and Rochford. *Ownership:* W. E. Alyea, J. R. Graves, and S. P. Gantz, Mystic, S. Dak. *Property:* 4 unpatented claims, approximately 55 acres. *Type of Deposit:* Bench Placer. *Ore:* Gold. *Development:* None. *Remarks:* Not operating at present; some work done here in 1935.

FEBRUARY GROUP: *Location:* 3 miles southeast of Hill City. *Ore:* Tin. *Reference:* (15).

FERGUSON PLACER: *Location:* Near Hayward. *Valuable Mineral:* Andalusite and Sillimanite.

FERN CLIFF: *Location:* $\frac{1}{2}$ mile north of Spokane Mine, 7

miles east of Harney Peak. Formerly owned by F. G. Robertson. *Property*: 1 unpatented claim, approximately 20 acres. *Type of Deposit*: A pegmatite lying in a region of lithia-bearing pegmatites, containing primary scheelite. *Ore*: Tungsten. *Remarks*: A prospect.

FIRST FIND CLAIM: *Location*: 2 miles east of Oreville. *Ore*: Tin. *Reference*: (15).

FLORA CLAIMS: *Ore*: Tin. *Reference*: (15).

FOREST CITY CLAIM: *Location*: 1½ miles east of Oreville. Formerly the Clara Belle. See Golden Arrow Mine.

FOREST CITY GOLD MINE: See Empire Gold Mines, Inc.

FREE GOLD MILLING CO.: *Ore*: Gold and some Silver. *Reference*: (12).

GERTIE TIN MINE: Formerly owned by the Harney Peak Tin M. M. & Mfg. Co., also Gertie Mining Co. *Location*: ½ mile south of Hill City townsite, in an unorganized mining district. *Present Owners*: E. C. Johnson heirs, Chicago, Ill. *Property*: 2 patented claims. *Type of Deposit*: Pegmatite dike. *Ore*: Tin. *Development*: 500'—40° incline and 200' tunnel along the strike of the dike, also additional drifting. *Production*: A mill was erected on the property in 1905 and 1907; most of the machinery has since been removed from the property. *Remarks*: Idle since 1908.

GIRA'S CLAIM: *Location*: 4½ miles northeast of Hill City, in an unorganized mining district. *Property*: 1 unpatented claim, approximately 20 acres. *Type of Deposit*: Quartz vein in pre-Cambrian schist. *Ore*: Tungsten. *Development*: A 30' shaft sunk along the dip of the vein. *Remarks*: A prospect. *Reference*: (16).

GLENDALE GROUP: *Location*: 3 miles southeast of Keystone. *Ore*: Tin and Beryl. *References*: (15), (19).

GOLDEN ARROW MINES: Formerly Clara Belle Mine. *Location*: Unorganized mining district, 7 miles south of Hill City. *Ownership*: Lester Anthony Gira, Custer, S. Dak.,

Bernard Gira, Camp Crook, S. Dak. *Property*: 13 unpatented claims, approximately 120 acres. *Type of Deposit*: Fissure vein. *Ore*: Gold and some Silver. *Development*: Vertical shaft 250'; inclined shaft 97' vertical depth. *Remarks*: Idle since 1911.

GOLDEN SLIPPER MINE: See Empire Gold Mines, Inc.

GOLDEN SUMMIT: Formerly the Gold Mint. *Location*: In an unorganized mining district, $3\frac{1}{2}$ miles east of Hill City. *Ownership*: Mr. C. E. McEachron, Hill City, S. Dak. *Property*: 5 patented claims, 50 acres. *Type of Deposit*: Fissure vein. *Ore*: Gold and some Silver. *Development*: A 300' shaft, 400' of drifting and crosscutting. *Mine Plant*: 1 small steam hoist and a large steam hoist (Chicago Iron Works), 2 Cameron sinker pumps. *Power*: One 80 HP boiler and one 100 HP boiler. *Remarks*: Idle since 1917.

GOLDEN VALLEY PLACER: *Location*: Unorganized mining district, $3\frac{1}{2}$ miles south of Rochford. *Ownership*: John P. Widner, Rochford, S. Dak. *Property*: 1 unpatented claim, approximately 20 acres. *Type of Deposit*: Bench Placer. *Ore*: Gold. *Development*: Developed by open pits. *Remarks*: One-man operation.

GOLDEN WEST MINE: *Location*: 5 miles west of Rochford. *Ownership*: Dr. Alfred O. Peterson, 616 Medical Arts Building, Omaha, Neb. *Property*: 10 patented and 3 unpatented. *Type of Deposit*: Replacement in cummingtonite schist. *Ore*: Gold and some Silver. *Development*: Large open cut, tunnels and other workings; 6-mile flume abandoned; 15 drill holes have been put down to a depth of 150'. *Remarks*: Property inactive, oxidized rock largely removed, a vein of diorite 4' wide and about 40' thick has been opened up.

GOLD HILL: Formerly the Gold Lode. *Location*: In an unorganized mining district, $4\frac{1}{2}$ miles northwest of Hill City. *Local Representative and President*: Dr. G. C. Redfield, Rapid City, S. Dak. *Incorporated*: South Dakota, Nov., 1929. *Capital Stock*: 1,000,000 shares, par value \$1.00, 250,000 shares issued. *Property*: 10 unpatented claims, approxi-

mately 200 acres. *Type of Deposit:* Shear zone. *Ore:* Gold and some Silver. *Development:* 95' shaft with drifts and crosscuts and shallow workings exposing lode for 3,000'. *Remarks:* Assessment work only. Recently examined for RFC loan.

GOLD KING MINING COMPANY: On Silver Creek near Rochford. *Ownership:* Verda P. Schneerer, J. R. Russell, J. Hogarth, A. Hoffman, all of Deadwood, S. Dak. *Property:* 19 unpatented claims, approximately 380 acres. *Ore:* Gold and some Silver. *Development:* By 4 shafts, 185', 100', 85' and 50' in depth. *Mine Plant:* Hoist and compressor. *Mill:* 10 stamps. *Power Plant:* Two 75 HP boilers. *Remarks:* Idle since 1918.

GOLD LODGE: See Gold Hill.

GOLD MINT: See Golden Summit.



Figure 34. Good Luck Tungsten Mine near Hill City

GOOD LUCK PROPERTY: Formerly American Tungsten Mining Co. *Location:* 4 miles east of Hill City in an unorganized mining district. *Ownership:* Mr. Arthur Wabel,

Hill City, S. Dak. *Property*: 4 patented claims and 4 unpatented claims, approximately 148 acres. *Type of Deposit*: 3 quartz veins cutting pre-Cambrian schist with muscovite well developed along the border and in seams in quartz. *Ore*: Tungsten (wolframite, ferberite, and a little scheelite). *Development*: A 25' shaft and several open cuts exposing the vein for a distance of 75' along its strike on the Success claim. A 100' shaft with 97' of drifting at the 40' level and 28' of crosscutting at the bottom of the shaft, also a winze from the 40' level near the main shaft sunk to a depth of 30', also a small shaft. On the Cleveland Lode the vein is exposed for a distance of 40' along its strike by open cuts. *Mine Plant*: No. 7 Cameron sinker pump, and about 600' of pipe. *Power*: A 60 HP steam boiler. *Mill*: 10-stamp concentrating plant (table), not complete. *Remarks*: Operating at present, cleaning old workings and repairing mill.

GOPHER LODGE: *Location*: In an unorganized mining district, 17 miles southwest of Rochford. *Ownership*: Mr. Ole Soholt, Deerfield, S. Dak., and Mr. Mart Ebner, Hill City, S. Dak. *Property*: 5 unpatented claims, and one patented claim, (Gopher Lode) and millsite, approximately 150 acres. *Type of Deposit*: Fissure vein. *Ore*: Copper, Gold and some Silver. *Development*: 80' of tunneling, and 2 small open cuts. *Remarks*: Idle at the present time.

GRAND MINE: See Rockne and Amber.

GRANITE CLAIMS: *Location*: Near Keystone. *Type of Deposit*: Pegmatite. *Valuable Mineral*: Beryl. *Reference*: (19).

GREAT WONDER: *Ore*: Tungsten. *Reference*: (5).

GREENBACK MINE: *Location*: In an unorganized mining district, 2 miles north of Hill City. *Ownership*: Fred and Harry Mills, Hill City, S. Dak. *Property*: 3 unpatented claims, approximately 20 acres. *Type of Deposit*: Fissure vein. *Ore*: Gold and some Silver. *Development*: 2 shafts 60' and 20' in depth. Several open cuts. *Remarks*: Assessment work only.

GRUB STAKE PLACER: See Last Chance Placer.

HALCYON MINING COMPANY: Formerly the Joe Dollar Mine. *Location:* In an unorganized mining district, 6 miles east of Hill City. *Local Representative:* Mr. L. A. Frankforter. *Officers:* President, Dave Carter; Secretary, C. R. Woodroof, Polo Illinois. *Incorporated:* South Dakota, 1912. *Capital Stock:* 750,000 shares having a par value of \$1.00. *Property:* 11 unpatented claims. *Type of Deposit:* Fissure vein. *Ore:* Gold and some Silver. *Development:* 1,650' of tunnels. *Mine Plant:* 1 "Jackhammer", 2 cars having a capacity of 14 cubic feet, fan equipped with 1,500' of 8" galvanized pipe. *Mill:* 10-stamp mill, 1 gas driven compressor. *Power:* 15-30 International and a 3½ HP Gas Engine. *Remarks:* Intermittent prospecting and exploration.

HARDESTY: *Location:* 4 miles northwest of Hill City. *Ownership:* Mrs. Emma K. Hardesty, Keystone, S. Dak. *Property:* 4 patented claims, approximately 160 acres. *Type of Deposit:* Pegmatite. *Valuable Mineral:* Soda Feldspar, Beryl, Mica, Lepidolite, Feldspar and Amblygonite. *Development:* 1 open cut 320 sq. ft. in area and 20' in depth. *Remarks:* Idle since 1935.

HARNEY PEAK TIN MINING, MILLING AND MFG. CO.:
See National American Tin Corporation.

HAYES CLAIM: See White Swan.

HEART OF THE BLACK HILLS: Formerly the Black Hills Tungsten M. & M. Co., also Elkhorn Tungsten Co. *Location:* 4 miles east of Hill City, unorganized mining district. *Ownership:* G. E. Dyer and George Bland, Hill City, S. Dak. *Property:* 3 unpatented claims, approximately 60 acres. *Type of Deposit:* 5 veins of tungsten-bearing quartz in pre-Cambrian schist. *Ore:* Tungsten. *Development:* One 100' shaft; 120' of drifting at the 90' level and 20' of crosscutting; a 90' raise at the end of the 120' drift. *Remarks:* Idle since 1918. *Production:* 1913-\$3,000; 1914-\$400; 1916-\$10,000. *Reference:* (16).

HEBERT PROPERTY: See Tin City Mine and Tin Queen Mine.

HIGH CLIMB: *Location:* $\frac{3}{4}$ mile from Oreville, near the Custer and Pennington County line. *Ownership:* Fred Heidepreim and John Wells, Custer, S. Dak. *Property:* 1 unpatented claim, approximately 20 acres. *Type of Deposit:* Pegmatite. *Valuable Mineral:* Amblygonite, Mica and Columbite. *Development:* Worked by open cuts. *Remarks:* Intermittent operation at the present time. *Reference:* (4).

HIGH LODGE: *Location:* On east side of Summit Peak, 2 miles southeast of Hill City. *Ownership:* Del Canfield, Hill City, S. Dak. *Property:* 1 unpatented claim. *Type of Deposit:* 4 quartz veins from 1 inch to 12 inches in width cutting a pegmatite. *Ore:* Tungsten. (Wolframite). *Development:* Small open cuts. *Remarks:* A prospect. *Reference:* (16).

HILL CITY TUNGSTEN PRODUCERS CO.: See National American Tin Corp.

HOMELODE MINE: See Jenny Gulch Mining Co.

HOODOO: *Location:* In unorganized mining district, $4\frac{1}{2}$ miles southwest of Mystic. *Ownership:* Charles Roland, Joe Simpson, Hill City, S. Dak., and George Sutton Estate. *Property:* 3 claims, unpatented (20 acres each) and 120 acres of patented ground. *Type of Deposit:* Ancient channel placer. *Ore:* Gold. *Development:* Shafts, drifts, and crosscuts. *Production:* 1930-1935-\$4,800. *Remarks:* This property is being worked by leasers. Small scale operations.

HOPEFUL PETER: See Real Green Granite Quarry.

HOPEFUL TIN PROPERTY: Formerly Samelias Mine, and formerly owned by Harney Peak Tin M. M. & Mfg. Co. *Present Owners:* G. H. Hardesty and B. A. Hardesty, Keystone, S. Dak. *Location:* 4 miles west of Keystone, in unorganized mining district. *Property:* 2 unpatented claims, approximately 40 acres. *Type of Deposit:* 2 lenticular quartz shoots. *Ore:* Cassiterite. *Development:* 2 shafts, each having a depth of approximately 100', also drifting.

Remarks: A considerable amount of exploration was done on this property by the Harney Peak Tin M. M. & Mfg. Co. Assessment work only at the present time.

HUGO MINE: *Location:* 1½ miles south of Keystone. *Ownership:* Hugo Reinbold. Leased by Consolidated Feldspar Co., which see. *Type of Deposit:* Pegmatite. *Ore:* Feldspar and some Columbite. *Development:* Glory hole and open cut methods employed. *Remarks:* Operating and employing 70 men. This mine is the source of feldspar for the Consolidated Feldspar plant at Keystone.

INGERSOLIAN: *Ore:* Tin. *References:* (2) (15).

JACKSON AND TOP SHEAF: Located 1 mile east of Hill City. Formerly owned by Harney Peak Tin M. M. & Mfg. Co. Now property of National American Tin Corp., which see. *Ore:* Tin. *Reference:* (15).

JENNY GULCH MINING COMPANY: Formerly the Homelode Mine. *Location:* 3 miles north of Silver City, in unorganized mining district. *Local Representative:* John O'Brien, Silver City, S. Dak. *Officers:* Charles Shockley, President; Sam O'Brien, Secretary, Alliance, Nebraska. *Incorporated:* South Dakota, 1935. *Capital Stock:* 1,000,000 shares of \$1.00 par value, none issued. *Property:* 8 unpatented claims, approximately 160 acres. *Type of Deposit:* Fissure vein. *Ore:* Gold, Silver, Antimony and some Arsenic. *Development:* 220' shaft and 300' of drifting. *Mine Plant:* 10" Cameron sinker and a No. 8 Cameron sinker. *Mill Plant:* 10' Lane Mill, Gates Crusher and concentrating table. *Power:* Two 80 HP boilers. *Remarks:* No production since 1917. Doing exploratory work at present.

JENSSEN MINE: *Locations* 2½ miles southwest of Keystone. *Ore:* Mica. *Reference:* (5).

JOE DOLLAR MINE: See Halcyon Mining Co.



Figure 35. The Johnson Limestone Quarry at Rapid City

JOHNSON QUARRIES: *Location:* Near Rapid City on Black Hawk road 1 mile from South Canyon junction. *Ownership:* Oscar W. Johnson, 611 Eleventh Street, Rapid City, S. Dak. *Property:* 5 acres patented. *Type of Deposit:* Minnekahta limestone of good quality. *Valuable Material:* Minnekahta limestone. *Development:* Side hill quarry. *Mine Plant:* Ingersoll Rand single-stage 3-drill compressor, operated by tractor motor. *Treatment Plant:* A 100-ton crushing and screening plant being installed. *Power:* Gasoline motors. *Production:* 3,750 cu. yds. of crushed rock. First sales December 1st, 1935.

JOLLY GROUP: *Location:* 3 miles east of Hill City. *Property:* 3 patented claims, approximately 30 acres. Formerly owned by Stephens Tin Co. *Ore:* Tin.

J. R. MINE: (Crocker). Last operation by Cumberland Mining and Milling Co. *Location:* 3 miles east of Hill City. *Local*

Representative: Jack Crocker, Hill City, S. Dak. *Officers:* Secretary, J. W. Fowler, Address unknown. *Incorporated:* South Dakota, 1902. *Capital Stock:* 1,500,000 shares having a par value of \$1.00. *Stock Issued:* 1,500,000 shares. *Property:* Six and a fraction claims, about 50 acres of which is patented. *Type of Deposit:* Fissure vein in pre-Cambrian slates and schist. *Ore:* Gold and some Silver. *Development:* 350' shaft—no figures on drifting, etc. *Mill Plant:* 5 stamps in need of repairing. *Power:* Two 60 HP steam boilers. *Remarks:* Idle since 1908.

JUNIPER GROUP: *Location:* In the Keystone Mining district, 2 miles north of Keystone... *Ownership:* Mr. John Snowie and Mr. W. H. Graham, Keystone, S. Dak. *Type of Deposit:* Shear zone. *Ore:* Gold and some Silver. *Development:* 69' tunnel on Juniper claim, connected by 62' vertical raise with 50' open cut and 20' tunnel above, and by 50' inclined shaft with underground workings. Several small shafts on other claims.

KEYSTONE CONSOLIDATED MINES, INC.: *Location:* In Keystone Mining District near Keystone. *President:* Lewis Byron, Jr. *Resident Engineer:* A. I. Johnson. *Incorporated:* South Dakota, Aug. 3, 1927. *Capital Stock:* 2,500,000 shares. *Par Value:* \$1.00. *Shares Issued:* 1,750,000. *Property:* Owns Holy Terror Group, Keystone Group, Gracie Lode, Reed Placer. *Type of Deposit:* Quartz veins in graphitic slates and schist. *Valuable Minerals:* Gold and Arsenic. *Development:* 1,200' shaft on Holy Terror; 500' shaft on Keystone, considerable drifting. Workings said to total 15,000'. *Remarks:* Idle since 1903; closed by litigation. Recent development; 420' tunnel on Keystone ledge. *Production:* Keystone Mine: Above 180' level—46,000 tons mined produced \$273,140, 1892-1897—70% recovery. Holy Terror Moning Co.: 1894-1895, \$32,000; 1896, \$58,775; 1897, \$174,451.38; 1898, \$268,507.53; 1899, \$301,563.36; 1900, \$126,807.75; 1901, \$140,522.21; 1902 \$122,060.50; 1903, est. \$60,000.

KEYSTONE FELDSPAR AND CHEMICAL CO.: *Type of Deposit:* Pegmatite. See Peerless Mine. *Reference:* (13).

KING MICA CO.: *Location:* 3 miles southeast of Keystone. Formerly Otho Power and Development Co., also Glendale Mining and Milling Co. *Ownership:* Fred Robertson. *Property:* 700 acres of which 100 acres is patented, on Etta Hill. *Type of Deposit:* Pegmatite. *Ore:* Gold, Silver, Tin, Lead, Lithia and Mica. *Development:* By shafts and tunnels; 100-ton mill erected in 1914. *Production:* Shipped car load of mica in 1935.

KING MIDAS PLACER: *Location:* On Rapid Creek in Canyon City Gulch. *Remarks:* Hydraulicking here during summer of 1934. *Reference:* (20).



Figure 36. The King of the West Mine near Rochford

KING OF THE WEST MINING COMPANY: *Location:* $4\frac{1}{2}$ miles southwest of Rochford. *Local Representative:* Clifford L. Curran, Rochford, S. Dak. *Operating Staff:* Clifford L. Curran, Rochford, S. Dak., Gen. Mgr. and Engr., John Renning, Mill Supt. *Officers:* James L. Curran, President; Albert F. Gushurst, Vice-President; Harold J. Shea, Secretary; Clifford L. Curran, Treasurer. *Incorporated:* South Dakota, 1934. *Capital Shares:* 150,000 having no par value, 140,000 shares issued. *Property:* 16 unpatented claims,

approximately 300 acres. *Type of Deposit:* Replacement. *Ore:* Gold and some Silver. *Development:* Open cut, main shaft 160' in depth, additional shaft and winze 40', 460' of drifts and crosscuts, 800' of diamond drill holes. *Mine Plant:* Air compressor, steam hoist, drifter, sinker and stoper, drills, diamond drill, 1½ KW steam turbo-generator lighting plant, 3 steam pumps, 1 electric pump. *Power:* Oil-fired steam boiler, 150 HP Diesel Electric Plant. *Mill Plant:* 50 tons all-slime cyanide plant, crusher, ball mill, classifier, thickeners, agitators. New plant went into operation Feb. 1, 1935. 28 men employed.

LAST CHANCE PLACER: Formerly the Grub Stake Placer. *Location:* 7 miles north of Hill City, near Redfern in an unorganized mining district. *Ownership:* Mr. Ed. Riding, Hill City, S. Dak. *Property:* 1 unpatented claim, approximately 20 acres. *Type of Deposit:* Bar placer. *Ore:* Gold. *Remarks:* Intermittent, small scale operation.

LEGAL TENDER GROUP: (Legal Tender; Ramshorn, Hepburn, Battle Creek Placer, Wonder, Wonder No. 1.) *Location:* 1½ miles west of Keystone on Battle Creek. *Ownership:* Mrs. M. M. Gerard. *Property:* 6 patented claims, approximately 64 acres. *Type of Deposit:* Shear zone and placer. *Ore:* Gold and some Silver. *Development:* Shaft on Ramshorn 65' deep with rich streak from top to bottom of shaft, specimen ore. 2 tunnels on Wonder, one 150' long, another 50' long, numerous other shafts and tunnels. *Remarks:* Idle at the present time.

LONE STAR PLACER: *Location:* In an unorganized mining district in the vicinity of Redfern, 6½ miles north of Hill City. *Ownership:* Mr. Ben Hubbard, Hill City, S. Dak. *Property:* 1 unpatented claim, approximately 20 acres. *Type of Deposit:* Gulch placer. *Ore:* Gold. *Development:* Several shallow test pits. *Remarks:* Rocker and pan method employed. 2 men working intermittently.

LUCKY STRIKE GROUP: *Location:* 1 mile east of Keystone on Battle Creek. *Ownership:* A. I. Johnson, Keystone, S.

Dak. *Property:* 2 unpatented placer claims, 40 acres, and 1 unpatented lode claim east of the Etta Mine, approximately 20 acres. *Type of Deposit:* 2 placer and one fissure type. *Ore:* Gold. *Development:* Test pits on placer claims and test pits and 25-foot shaft on lode claim.

MARGARET: See Cobalt.

MARIGOLD MINING AND MILLING COMPANY: *Location:* 5 miles west of Rochford, in unorganized mining district. *Officers:* President, George H. Stewart, Lead, S. Dak., Secretary, Walter O. McClintock, Rochford, S. Dak. *Incorporated:* Delaware, 1933. *Capital Stock:* 500,000 shares having a par value of \$1.00. *Property:* 40 unpatented claims, approximately 800 acres. *Type of Deposit:* Fissure vein in broken slate and schist. *Ore:* Gold and some Silver. *Development:* 2 shafts, 150' and 50' in depth. *Mine Plant:* 2 steam hoists, 1 Denver sinker, 3 drifters, 1 stoper, 2-½ ton cars, 1 sinking pump, 1 boiler pump, 1 station pump, 1 Cameron No. 2 Compressor. *Power:* Three 80 HP DC generators. *Remarks:* Employed 13 men during the summer of 1935, doing exploration work.

MARTHA WASHINGTON CLAIM: Formerly owned by C. H. Kammon, deceased. *Location:* 4½ miles southeast of Hill City, in unorganized mining district. *Property:* 1 unpatented claim, approximately 20 acres. *Type of Deposit:* Quartz veins in pre-Cambrian schist. *Ore:* Tungsten. *Development:* A 100' prospect trench along the strike of one vein; a 25' prospect trench along the strike of another vein. *Remarks:* This is a prospect.

MARY ANN PLACER: *Location:* 2 miles east of Mystic, in an unorganized mining district. *Ownership:* Mr. D. P. McCormick, Mystic, S. Dak. *Property:* 1 unpatented claim, approximately 20 acres. *Type of Deposit:* Bar placer. *Ore:* Gold. *Development:* Open pits and drift-mining employed. *Remarks:* Working intermittently, employing 2 men.

MATTEEN CLAIM: *Location:* ½ mile east of Hill City. *Ore:* Tin. *Reference:* (15).

MAYWOOD CHEMICAL WORKS: Formerly the Standard Essence Co., Maywood, N. J. Own and operate the Etta Mine at Keystone, which see, and Empire Lode, Fractional Tin, Tin Mountain Lode, and Maywood Claim. *Valuable Mineral:* Lithium. *Reference:* (13).

McKINNON AND MILLER'S CLAIM: *Location:* 4½ miles southeast of Hill City. *Property:* 1 unpatented claim, approximately 20 acres. *Type of Deposit:* Pegmatite, wolframite occurring in quartz segregation within the dike. *Ore:* Tungsten (wolframite). *Development:* The pegmatite has been opened by test pits for a distance of about 200' along the strike. *Remarks:* A prospect.

MEWONITOC: *Location:* 1 mile east of Hill City. Formerly owned by Harney Peak Tin M. M. & Mfg. Co. *Ore:* Tin. *References:* (14) (30) (85).

MICHIGAN PLACER: Formerly owned by Ed Nelson, deceased. *Location:* 4½ miles southeast of Hill City on Palmer Gulch, in an unorganized mining district. *Present Owners:* Nelson heirs. *Type of Deposit:* Wolframite occurs in a sill of pegmatite and in a vein of quartz. *Ore:* Tungsten (wolframite). *Development:* Several small test pits. *Remarks:* A prospect.

MIDNIGHT MINING CO.: *Location:* Near Silver City. *Ore:* Gold, Lead, Antimony and some Silver. *Remarks:* Letter returned from former address. *Reference:* (12).

MILLS PROPERTY: See Wolfram Lode.

MILLS TUNGSTEN CLAIM: Formerly owned by Fred and Harry Mills, Hill City, S. Dak. *Location:* 1 mile east of Hill City. *Property:* 1 unpatented claim, approximately 20 acres. *Type of Deposit:* Quartz veins occurring in a graphitic schist. *Ore:* Tungsten (wolframite). *Development:* A 25' shaft at the north end of the vein. *Remarks:* A prospect.

MINES FINANCE AND DEVELOPMENT SHARES, INC.: *Address:* Rapid City, S. Dak. *Incorporated:* South Dakota, 1936. *Capital Stock:* \$1,000,000. *Officers:* Charles H.

Reed, Rapid City, S. Dak., President; Julius Schumacker, Rapid City, S. Dak., Vice-President; John Merritt, Rapid City, S. Dak., Secretary-Treasurer; A. I. Johnson, Keystone, S. Dak., Resident Engineer. *Property*: Bismark and Ida Florence Group, (Which see).

MOHAWK TIN MINE: Property of the National American Tin Corp., which see. *Location*: $\frac{1}{2}$ mile west of Hill City in an unorganized mining district. *Property*: 4 patented claims, approximately 50 acres. *Type of Deposit*: Pegmatite with cassiterite occurring in irregular quartz-mica lenses throughout the dike. *Ore*: Tin. *Development*: 3 shafts; No. 1, a two-compartment inclined shaft, depth 100'; No. II, a single-compartment inclined shaft, depth 42'; No. III, inclined, depth 64'. One tunnel, cross-section 5' x 7', 129' in length. Approximately 150' of drifting and crosscutting. *Remarks*: Idle since 1922.

MOUNTAIN BOY: *Ore*: Tin. *Reference*: (15).

MYSTIC PLACER: *Location*: In an unorganized mining district in the vicinity of Mystic. *Ownership*: Mr. and Mrs. George Frink, Mystic, S. Dak. *Property*: 3 unpatented claims, approximately 60 acres. *Type of Deposit*: Bar placer. *Ore*: Gold. *Development*: Shallow shafts and short drifts. *Remarks*: Operating, employing one man.

NAIAD QUEEN CLAIM: *Location*: 6 miles southwest of Hill City. Formerly owned by Harney Peak Tin M. M. & Mfg. Co. *Ore*: Tin. *Reference*: (15).

NATIONAL AMERICAN TIN CORPORATION: A consolidation of American Tin and Tungsten So. and National Tin Corporation. *Officers*: Simon Lederer, President (deceased). *Incorporated*: March 11, 1929, in Delaware. *Capital Stock*: 600,000 shares. *Par Value*: \$5.00. 486,349 shares issued. *Property*: Cowboy, Mohawk, Tin Boom mines. *Reference*: (15).

NATIONAL TIN CORPORATION: See National American Tin Corporation.

NEVADA: *Ore:* Tin. *Reference:* (15).

NEW ELDORADO MINES, INC.: Formerly the Eldorado Mine. *Location:* In unorganized mining district 5 miles east of Hill City. *Officers:* President, Dr. A. Karsten, Rapid City, S. Dak.; Vice-President and General Manager, Ludlow G. Anderson, Rapid City, S. Dak.; Secretary and Treasurer, J. W. Bordewyk, Rapid City, S. Dak. *Incorporated:* South Dakota, 1936. *Capital Stock:* \$100,000. *Par Value:* \$1.00. *Property:* 3 patented claims, approximately 35 acres. *Type of Deposit:* Fissure vein. *Ore:* Gold and some Silver. *Development:* 2 shafts, 200' and 85' in depth; 280' of drifting and crosscutting. *Production:* 1896, 50 tons having a total value of \$1,000. 1897, 30 tons, having a value of approximately \$522; 30 tons, \$450; 200 tons, approximately \$2,000. *Remarks:* Idle from 1898 to 1936. Exploration work at the present time; recently purchased a new 25-ton capacity Ellis mill.

NEW SILVER DOLLAR: Formerly the Oreo. *Location:* In unorganized mining district, 5 miles east of Hill City. *Ownership:* Mr. Bob Maiwold, Hill City, S. Dak., and Mr. Wm. Graham, Keystone, S. Dak. *Property:* 3 unpatented claims, approximately 60 acres. *Type of Deposit:* Fissure vein. *Ore:* Gold and some Silver. *Development:* 160' incline with 130' of crosscutting. *Remarks:* Idle since 1910.

NICHOLS: *Location:* 3½ miles southeast of Keystone near Hayward. *Type of Deposit:* Pegmatite. *Ore:* Lithium minerals. *Reference:* (11).

NORTHWESTERN QUARRY CO.: *Location:* 4½ miles west of Rapid City, in unorganized mining district. *Local Representative:* R. H. Lee, Rapid City, S. Dak. *Type of Deposit:* Sedimentary. *Valuable Material:* Minnekahta limestone. *Development:* Open cut system employed. *Treatment Plant:* Crushing plant. *Power:* Electricity, Dakota Power Co. *Remarks:* Working intermittently, employing 4 men.



Figure 37. The Limestone Quarry of the Northwestern Quarry Company at Rapid City

NUGGET AND GOLDEN PLACER: *Location:* 3 miles south-west of Mystic, in an unorganized mining district. *Ownership:* Mr. John R. Drew and Eva M. Drew, Mystic, S. Dak. *Property:* 2 unpatented claims, approximately 40 acres. *Type of Deposit:* Bar placer. *Ore:* Gold. *Development:* Several short drifts and small open cuts. *Remarks:* Assessment work only.

NUGGET BAR: *Location:* 3 miles east of Pactola in an unorganized mining district. *Ownership:* Mr. P. J. Nepper, Rapid City, S. Dak. *Property:* 1 unpatented claim, approximately 20 acres. *Type of Deposit:* Bar and creek placer. *Ore:* Gold. *Development:* Worked by shafts, and open cuts. *Remarks:* Working intermittently, employing 2 men.

O. K. LODGE: *Location:* In unorganized mining district, 5 miles north of Hill City. *Ownership:* Elmer Hoisington and Dell Woods, Keystone, S. Dak., Mr. and Mrs. George B. Grant,

Custer, S. Dak. *Property*: 3 unpatented claims, approximately 60 acres. *Type of Deposit*: Shear zone. *Ore*: Gold and some Silver. *Development*: 3 shafts, 135', 70' and 30' in depth, 320 sq. ft. of open cuts. *Production*: 1923, 100 tons netted \$771.00; 1924, 90 tons netted \$938.60. *Remarks*: Idle since 1929.

OLD BILL MINE: *Location*: 4½ miles northeast of Hill City, in unorganized mining district. *Ownership*: Mr. W. O. Canfield, Hill City, S. Dak. *Property*: One unpatented claim, approximately 20 acres. *Type of Deposits* Shear zone. *Ore*: Gold and some Silver. *Development*: Several small open cuts. *Remarks*: Assessment work only.

OLD ROBIN PLACER: *Location*: 6 miles south of Mystic, in an unorganized mining district. *Ownership*: Messrs. Jack Hendrickson and R. E. Prickett, Mystic, S. Dak., and J. M. Adair, Salt Lake City, Utah. *Property*: One unpatented claim, approximately 20 acres. *Type of Deposit*: Creek and bar placer. *Ore*: Gold. *Development*: Several shallow pits. *Remarks*: Assessment work only.

OLD ST. ELMO: See Western Belle.

OLYMPIA: *Location*: 2½ miles southwest of Hill City, formerly owned by Harney Peak Tin M. M. & Mfg. Co. *Type of Deposit*: Pegmatite. *Ore*: Tin.

OREO: See New Silver Dollar.

OREO ANNEX: *Location*: In unorganized mining district, 5½ miles northwest of Keystone. *Ownership*: Richard Jatko and Charles Thompson, Keystone, S. Dak. *Property*: 1 unpatented claim of approximately 20 acres. *Type of Deposit*: Fissure vein. *Ore*: Gold and some Silver. *Development*: Several trenches and test pits. *Remarks*: Assessment work only.

OTHO POWER AND DEVELOPMENT CO.: See King Mica Co.

OTTUMWA: *Location*: 4 miles east of Hill City. *Type of Deposit*: Pegmatite. *Ore*: Tin. *References*: (3) (5).

PAHASA MINING CO.: See National American Tin Corporation.

PA-HA-SA-PA MINING CO.: *Ore:* Gold and some Silver.
Reference: (14).

PAY-DAY MINE: Formerly the Sunbeam Mine. *Location:* In unorganized mining district, 7 miles north of Hill City. *Ownership:* Mr. W. D. Woods, Keystone, S. Dak., and Mr. Carl Durand, Puposky, Minnesota. *Property:* 4 patented claims, approximately 80 acres. *Type of Deposit:* Fissure vein. *Ore:* Gold and some Silver. *Development:* 400' shaft, 500' of drifting and crosscutting. *Mine Plant:* One 15 HP hoisting engine, 2 steam pumps—2" discharge, 1 car 1,500 lb. capacity. *Power:* 80 HP boiler, compressor (steam run by a 50 HP steam engine), hoisting engine (10-15 HP). *Mill:* 10-ton Gibson mill (elliptic roll mill). *Production:* 1905, 45 tons, value, \$125 a ton. Summer of 1934, 26 tons, value, \$16 a ton. *Remarks:* Idle since 1911, except for a small amount of work done in the summer of 1934.

PEERLESS MINE: Formerly Keystone Feldspar and Chemical Company. *Location:* Keystone, S. Dak. *Type of Deposit:* Pegmatite. *Valuable Minerals:* Amblygonite, Feldspar, Spodumene, Beryl, Mica, and other pegmatite minerals. *Development:* By open cuts. *Remarks:* Being operated for lithium minerals, mica and soda-spar.

PETTIT AND PFANDER'S CLAIM: *Location:* 3 miles south-east of Hill City. *Property:* 1 unpatented claim, approximately 20 acres. *Type of Deposit:* Tungsten ore occurring along the walls of a fissure filled with gouge cutting a pegmatite dike. *Ore:* Tungsten (wolframite and scheelite). *Development:* Consists of a shaft 20' in depth and a cut into the face of the dike 25' long and 10' vertically, parallel to the main vein. *Reference:* (16).

PHYLLIS AND PHILIP CLAIMS: *Location:* Near Keystone. *Type of Deposit:* Pegmatite. *Valuable Mineral:* Beryl. *Reference:* (19).

PINE CREEK: *Location:* 8 miles southeast of Hill City. *Ore:* Tungsten. *Reference:* (16).

POISONED OX: See Copper Glance.

QUEEN BEE MINING CO.: *Location:* 8 miles northwest of Hill City. *Ownership:* Mrs. Harriet Langley, Rapid City, S. Dak. *Property:* 6 patented claims, approximately 64 acres. *Type of Deposit:* Shear zone. *Ore:* Gold and some Silver. *Development:* One 60' shaft, 150' of lateral workings; large open cuts. *Remarks:* Exploration work carried on in 1934.

RARE METALS COMPANY: *Location:* Oreville. *Ore:* Tin and tungsten. *References:* (15) (16).

REAL GREEN GRANITE QUARRY: Formerly Hopeful Peter, Mineral Stone and Placer. *Location:* 3 miles east of Pactola in unorganized mining district. *Ownership:* Mr. P. J. Nepper, Rapid City, S. Dak. *Property:* 3 unpatented claims, approximately 60 acres. *Valuable Mineral:* Green Granite. *Development:* Worked by shafts, crosscuts and open cuts. *Remarks:* 2 men employed clearing site for quarrying operations.

REFUGE ROCK AND GOLDEN REEF: *Location:* In unorganized mining district 3 miles east of Pactola. *Ownership:* Leon C. Nepper, Rapid City. *Property:* 1 unpatented claim, approximately 20 acres. *Type of Deposit:* Bar and creek placer. *Ore:* Gold. *Development:* Worked by shafts, crosscuts and open cuts. *Remarks:* Working intermittently, employing 2 men.

RHEINBOLD CLAIM: (Hill City). Formerly owned by Rheinbold Met. Co. *Location:* 5 miles south of Hill City, unorganized mining district. *Property:* 1 unpatented claim, approximately 20 acres. *Type of Deposit:* Tungsten ores are found on the contact between small veins of pegmatite and schist, in pegmatites, in seams of schist. *Ore:* Tungsten (hubnerite). *Development:* Consists of 1 inclined shaft 100' in depth and 6 small prospect cuts. *Production:* 1906—

\$1,400, estimated. *Remarks:* Idle since 1906. *Reference:* (16).

RHEINBOLD CLAIM: (Spokane). Formerly owned by Rheinbold Met. Co. *Location:* $\frac{1}{2}$ mile northwest of Spokane Mine. *Property:* 1 unpatented claim. *Type of Deposit:* Seams of quartz 1 inch to 18 inches in width cutting a pegmatite dike. *Ore:* Tungsten. *Development:* A shaft 50 feet in depth and several prospect cuts. *Remarks:* A prospect. *Reference:* (16).

ROCK LEDGE PLACER: *Location:* 1 mile south of Mystic, in unorganized mining district. *Ownership:* Mr. W. E. Brown, Mystic, S. Dak. *Property:* 1 unpatented claim, approximately 20 acres. *Type of Deposit:* Bar placer. *Ore:* Gold. *Development:* Drifts and small open cuts. *Remarks:* 2 men employed doing assessment work.

ROCKNE AND AMBER: Formerly the Grand Mine. *Location:* 8 miles northwest of Hill City. *Ownership:* Henry Kolln, Hill City, S. Dak. *Property:* 2 unpatented claims, approximately 40 acres. *Type of Deposit:* Shear zone (small quartz stringers in broken slate and schist). *Ore:* Gold and some Silver. *Development:* 5 shafts, ranging from 20 to 80' in depth, also several open cuts. *Mill:* 2 stamp, Allis Chalmer motor, 10 tons capacity. *Power:* Fordson Tractor. *Remarks:* Idle since Dec., 1934.

RUNDALL, MILLS & CASLER CLAIM: *Location:* 2 miles southeast of Hill City. *Property:* 1 unpatented claim. *Type of Deposit:* A small quartz vein in contact with pre-Cambrian schist. *Ore:* Tungsten (wolframite). *Development:* The vein is exposed by trenches and test pits for a distance of 100' along the strike. *Remarks:* A prospect. *Reference:* (16).

RUSHMORE CLAY PRODUCTS CO.: See Gergerson's Ranch and Smith Ranch, Custer County. *Location:* Rapid City, S. Dak. H. L. Jarchow, Jr., Local Agent.

SALLY CAVANAUGH: Formerly owned by Mrs. McDermott.



Figure 38. Limestone Quarry of the South Dakota State Cement Plant at Rapid City

dent. *Property*: 287.88 acres in Pennington County. *Type of Deposits*: Flat-lying sedimentary beds. *Valuable Materials*: Minnekahta limestone and Pierre shale. *Development*: Quarry and open pit methods of mining used. *Mine Plant*: 1 gasoline power well drill rig, 1 electric driven well rig, 1 gas fired steam shovel, 1 narrow gauge team locomotive, 25 side dump quarry cars, 3 type R39 Jackhammers, 6 standard gauge shale cars, air compressor, well drill bit sharpener, rock drill sharpener, forge, air receiver. *Treatment Plant*: 1 gyratory crusher, 1 swing hammer mill, 1 overhead electric clamshell crane, 2 compeb raw mills, 6 slurry tanks, 2 kiln feed tanks, 3 slurry pumps, 2 ferris wheel slurry feeders, 2 rotary kilns, 2 clinker coolers, 1 electric caterpillar tread clamshell, 1 preliminary grind mill, 2 compeb finish grind mills, 1 stock storage house, 2 packing machines, 8 conveyors, 4 cement elevators, 1 coal mill complete but not operated, 2 waste heat boilers, 2 economizers and superheaters, 1 auxiliary boiler, 2 turbo-generators, 2 jet condensers, 1 turbo-generator exciter set, 1 motor generator set, 2 switchboards, 3 transformers, 2 air compressors, 2 air

receivers, 2 boiler feed pumps, 2 general service pumps, 1 feed water heater, 1 water softening system, 1 cement chimney, 1 completely equipped machine shop, 1 standard gauge locomotive, 4 trucks, complete stock of smaller equipment and electric motors. *Power:* Steam-electric; gas; gasoline; fuel oil. *Production:* 1925-1935 inclusive, 4,902,545 barrels of cement. *Gross Sales:* \$11,906,975.25. *Remarks:* Operating average eight months a year since Dec., 1924, employing an average of 100 men.

SUCCESS CLAIM: Formerly the property of the American Tungsten Co., now a part of the Good Luck Property, which see. *Ore:* Tungsten. *Reference:* (16).

SUNBEAM MINE: See Payday Lode.

SUNDAY GULCH: *Location:* East of St. Elmo Peak. *Ore:* Tungsten.

SUNSET AND THOMAS PLACER CLAIMS: *Location:* In unorganized mining district in the vicinity of Placerville, 2½ miles northeast of Pactola. *Ownership:* Mr. Jesse Peck, Rapid City, S. Dak. *Property:* 2 unpatented claims, approximately 40 acres. *Type of Deposit:* Bar placer. *Ore:* Gold. *Development:* Open cut and sluicing systems used. *Remarks:* One man employed prospecting.

SUNFLOWER: Formerly the Battle Axe Mine. *Location:* In unorganized mining district, 4 miles west of Hill City. *Ownership:* Mr. Earl C. Burgette, Rapid City, S. Dak. *Property:* 4 patented claims, 80.64 acres. *Type of Deposit:* Fissure vein in pre-Cambrian slate and schist. *Ore:* Gold and some Silver. *Development:* 300' tunnel, 3 shafts, 85', 15' and 20' in depth. *Remarks:* Idle since 1885.

SUNSHINE PLACER: *Location:* ¼ mile south of Mystic in unorganized mining district. *Ownership:* Mrs. E. A. Wap-pick, Mystic, S. Dak. *Property:* 1 unpatented claim, approximately 20 acres. *Type of Deposit:* Bar Placer. *Ore:* Gold. *Development:* Several short tunnels. *Remarks:* Operating during summers, employing 2 men.

SUSAN IRENE PLACER CLAIM: *Location:* In unorganized mining district, on the outskirts of Mystic. *Ownership:* Mr. William Frink, Mystic, S. Dak. *Property:* 1 unpatented claim, approximately 20 acres. *Type of Deposit:* Bar and creek placer. *Ore:* Gold. *Development:* Open cuts and shafts used. *Remarks:* Assessment work only.

TENDERFOOT GROUP: Formerly owned by Cook and Rogers. *Location:* 6½ miles northwest of Custer. *Present Owner:* Bert Robinson, Custer, S. Dak. *Property:* 4 patented claims, approximately 40 acres. *Type of Deposit:* Pegmatite. *Ore:* Tin. *Development:* 996' tunnel, and a 600' tunnel. *Production:* Some production in the early 90's, but no record as to the amount. *Remarks:* Idle at the present time. *Reference:* (15).

TENDERFOOT PLACER: *Location:* 1 mile east of Mystic, in unorganized mining district. *Ownership:* Mr. Woodrow Brown, Mytic, S. Dak. *Property:* 1 unpatented claim, approximately 10 acres. *Type of Deposit:* Bar placer. *Ore:* Gold. *Development:* Drift system employed. *Remarks:* Assessment work only.

THE GILBERT PLACER: *Location:* In unorganized mining district, 2 miles south of Mystic. *Ownership:* John Benton, Mystic, S. Dak. *Property:* 1 patented claim of approximately 25 acres. *Type of Deposit:* Bar placer. *Ore:* Gold. *Development:* Drift system of mining employed. *Remarks:* Working intermittently.

TIGER: *Location:* 3½ miles east of Keystone. *Type of Deposit:* Pegmatite. *Ore:* Lithium minerals. *Reference:* (5).

TIN BOOM MINE: Property of the National American Tin Corporation, which see. *Location:* Adjoining Mohawk Group on the north, ½ mile west of Hill City in an unorganized mining district. *Property:* 5 patented claims, approximately 70 acres. *Type of Deposit:* Pegmatite with cassiterite occurring in irregular quartz shoots. Five orebodies said to have been crosscut, ranging in width from 2' to 6'. *Ore:* Tin. *Development:* 150' shaft, and approximately

1,500' of lateral workings, also several shallow shafts, and small open cuts. *Production*: Some production from here; no record as to the amount. *Remarks*: Idle since 1922. *Reference*: (15).

TIN CITY: Formerly owned by Frank Hebert, deceased. *Location*: Approximately 8 miles northwest of Custer, near Oreville, in an unorganized mining district. *Present Owners*: Frank Hebert heirs, San Diego, California. *Local Representative*: Joe Kurka, Custer, S. Dak. *Property*: 1 patented claim, approximately 20 acres. *Type of Deposit*: Pegmatite. *Ore*: Tin. *Remarks*: A prospect.

TIN HILL: *Location*: 2 miles southeast of Keystone. *Ore*: Tin. *Reference*: (15).

TIN KING: *Location*: 7 miles southwest of Hill City. *Ore*: Tin. *Reference*: (15).

TIN PLATE GROUP: *Location*: 4 miles southwest of Hill City. Formerly owned by Harney Tin M. M. & Mfg. Co. *Ore*: Tin. *Reference*: (15).

TIN QUEEN: Formerly owned by Frank Hebert, deceased. *Location*: 5 miles southwest of Hill City. *Ore*: Tin. *Reference*: (15).

TIN REEF: See Old Jeff Claim. *Ore*: Tin. *Reference*: (15).

TOM CUSTER GROUP: *Location*: 1 mile east of Keystone. *Ownership*: Mr. James L. Manion and Mr. David N. Swanzey, Keystone, S. Dak. *Property*: 1 unpatented claim and 7 patented claims, approximately 100 acres. *Type of Deposit*: Shear zone (small quartz stringers in pre-Cambrian slate and schist.) *Ore*: Gold and some Silver. *Development*: A 125' tunnel, also 4,000 sq. ft. of open cuts. *Remarks*: Idle since 1924.

TOM RILEY MANGANESE: *Location*: North of Pactola. *Ownership*: Tom Riley and A. C. Hunt. *Property*: 1 unpatented claim, approximately 20 acres. *Type of Deposit*: Replacement. *Ore*: Manganese oxide. *Development*: Assessment work only.

TUNGSTEN LODGE: Formerly owned by Wehrlick, Faust and Gowan. *Location:* 6 miles south of Hill City. *Property:* 1 unpatented claim, approximately 20 acres. *Type of Deposit:* Pegmatite. Tungsten mineral is most abundant in quartz and muscovite. *Ore:* Tungsten (wolframite). *Development:* Open cuts. *Remarks:* A prospect. *Reference:* (16).

TWIN SPRINGS PROPERTY: *Location:* 20 miles southwest of Rapid City, 5 miles east of Hill City. *Ownership:* Twin Springs Mining Co. *Officers:* President, Clark Ross; Secretary, Robert A. Gleason; Vice President, Hans Jacobson; Superintendent, J. E. Biddle. *Incorporated:* South Dakota, 1935. *Property:* 4 patented claims, area 78 acres. *Type of Deposit:* Quartz lenses in pre-Cambrian slates and schists. *Ore:* Gold and some Silver. *Development:* 50' shaft. *Mine Plant:* Hoists, drills and general equipment. *Remarks:* Doing development work, and sinking shaft at present.

UNION HILL MINE: Formerly the Buckeye and Lena Claims. *Location:* 4½ miles north of Hill City in an unorganized mining district. *Ownership:* George Coats and James Graham, Hill City, S. Dak. *Property:* 11 patented claims, approximately 144 acres. *Type of Deposit:* Shear zone, small quartz stringers in fractured slate and schist. *Ore:* Gold and some Silver. *Development:* 3 shafts, 165', 90', 100' in depth, several test pits and trenches, 2 tunnels, 1,258' and 150' long. *Mill:* 11 5-stamp batteries (need to be repaired). *Remarks:* This property has received the attention of several engineers, recently, many samples taken which gave favorable results. Has been idle since 1903.

UNKNOWN CAMP: *Location:* 5½ miles northeast of Pactola in unorganized mining district. *Local Representative:* J. Chas. Sherman, Pactola, S. Dak. *Property:* 16 patented and 2 unpatented claims, approximately 540 acres. *Type of Deposit:* Shear zone. *Ore:* Gold and some Silver. *Development:* 10,000 sq. ft. of open cuts; several shafts from 50' to 100' in depth, but all are inaccessible. *Mill:* 15 stamps not in operating order. *Remarks:* Idle since 1903.

URANIUM LODGE: See Copper Glance.

VIDA MAY CLAIM: Formerly owned by Pettit and Nash.
Location: $4\frac{1}{2}$ miles southeast of Hill City. *Property:* 1 unpatented claim. *Type of Deposit:* Quartz vein. *Ore:* Tungsten (wolframite). *Development:* By test pits and trenches. *Remarks:* A prospect. *Reference:* (16).

WESTERN BELL: Formerly the Old St. Elmo. *Location:* $6\frac{1}{2}$ miles south of Hill City, S. Dak. *Ownership:* Mr. J. A. Murphy and Mr. Robert E. Nelson, Hill City, S. Dak. *Property:* 3 unpatented claims of approximately 60 acres. *Type of Deposit:* Fissure vein. *Ore:* Gold and some Silver. *Development:* 120' tunnel, 120' of drifting and crosscutting. *Mine Plant:* One $\frac{1}{2}$ -ton hoist with 100' of $\frac{3}{4}$ " cable, 1 car and $\frac{3}{4}$ ton International truck. *Mill:* Two 650 lb. stamps, one 5" x 5" force pump, gravity table. *Power:* $1\frac{1}{2}$ HP gas engine. 1 Model T Ford engine. *Remarks:* Operating, employing 2 men.

WESTERN CHEMICAL REDUCTION CO.: *Ore:* Tin. *References:* (15) (16).

WHITE CAP MICA MINE: *Location:* Near Keystone. *Type of Deposit:* Pegmatite. *Valuable Mineral:* Beryl. *Reference:* (20).

WHITE SWAN: *Location:* Joins the townsite of Hill City on the east. *Ownership:* M. E. Hayes, Hill City, S. Dak. *Property:* 1 patented claim approximately $5\frac{1}{2}$ acres. *Type of Deposit:* Pegmatite. *Ore:* Tungsten (wolframite). *Development:* The dike has been prospected by open cuts for a total length of 200'. *Production:* Tungsten valued at \$300. *Remarks:* No work done here since 1918.

WHITE WHALE: *Location:* $1\frac{1}{2}$ miles southeast of Hill City. Formerly owned by Harney Peak Tin M. M. & Mfg. Co. *Reference:* (15).

WILMA MARIE PLACER: *Location:* $\frac{1}{2}$ mile east of Mystic, in unorganized mining district. *Ownership:* Mr. Cal Hale, Mystic, S. Dak. *Property:* 1 patented claim, approximately

20 acres. *Type of Deposit:* Bar placer. *Ore:* Gold. *Development:* By tunnels, pits and open cuts. *Production:* 1933 to date, 6 men working intermittently removed 600 cu. yds. having a total value of \$3,000. *Remarks:* Working intermittently employing 2 men.

WOLFRAM LODGE: Formerly owned by Fred and Harry Mills. *Location:* $\frac{1}{2}$ mile west of Hill City and 600' southeast of the Annie Claim. *Property:* 1 unpatented claim. *Type of Deposit:* Quartz vein from 2' to 3' in width cutting graphitic schist. *Ore:* Tungsten (wolframite) in small crystals. *Development:* Shallow trenches and test pits. *Remarks:* A prospect. *Reference:* (16).

WOODCHUCK: *Location:* In an unorganized mining district in the vicinity of Redfern, $6\frac{1}{2}$ miles northwest of Hill City. *Ownership:* Mr. W. D. Wood, Keystone, S. Dak., and Mr. M. S. Faulkner, Hot Springs, S. Dak. *Property:* 1 unpatented claim, approximately 20 acres. *Type of Deposit:* Shear zone. *Ore:* Gold and some Silver. *Development:* By open cuts. *Mill Plant:* 7" x 10" Blake Crusher. *Power:* 80 HP boiler, 30 HP engine. *Production:* 150 tons produced in 1932. *Remarks:* Idle since 1932.

YELLOW BIRD MINE: See Dexter Lode.

Perkins County

BUTTS COAL PROPERTY: *Location:* Near Bison. *Ownership:* J. P. Butts, Bison, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal. *Remarks:* Letters returned unclaimed.

CAZAR COAL PROPERTY: *Location:* Near Bison. *Ownership:* A. W. Cazar, Bison, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal. *Remarks:* Mine abandoned in 1929.

CLARK COAL PROPERTY: *Location:* Near Lodgepole. *Ownership:* S. M. Clark, Lodgepole, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal.

- DOERR COAL PROPERTY:** *Location:* Near Lodgepole. *Ownership:* Harry A. Doerr, Lodgepole, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal.
- FORREST COAL MINE:** *Location:* Near Lodgepole. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal.



Figure 39. The Hefner Coal Mine near Bison

- HEFNER-ROGERS COAL PROPERTY:** *Location:* Near Bison. *Ownership:* Frank Hefner, Simon Rogers, Bison, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal.
- HENDERSON COAL PROPERTY:** *Location:* Near Lodgepole. *Ownership:* C. R. Henderson, Lodgepole, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal.
- HYLLAND COAL PROPERTY:** *Location:* Near Bison. *Ownership:* H. N. Hylland, Bison, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal. *Remarks:* Abandoned 1932.
- JONES COAL MINE (J. C. GREY):** *Location:* Near Strool, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal.

KNUDSON COAL PROPERTY: *Location:* Near Strool.
Ownership: A. H. Knudson, Strool, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal.

KRUSCH COAL PROPERTY: *Ownership:* Alexander Krusch, Stickney, S. Dak.

LEASE COAL PROPERTY: *Location:* Near Bison. *Ownership:* Art Lease, Bison, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal. *Remarks:* Abandoned 1929.

MICHELSON COAL PROPERTY: *Location:* Near Lodgepole. *Ownership:* Hans Michelson, Lodgepole, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal.

PARKER COAL PROPERTY: *Location:* Near Lodgepole. *Ownership:* R. G. Parker, Lodgepole, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal.

SCHAR COAL PROPERTY: *Location:* 3½ miles from Strool. *Ownership:* George Schar, Strool, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal. *Remarks:* Not operating.

SEXTON AND CARLSON COAL PROPERTY: See Smith Coal Property.

SMITH COAL PROPERTY: Formerly Sexton Bros., Martin J. Sexton, and Carlsen Bros. *Location:* Near Bison. *Ownership:* J. P. Smith, Bison, S. Dak. *Mineral:* Lignite coal.

STILLMAN-FITZGERALD PROPERTY: *Location:* Near Chance. *Ownership:* Morton Stillman, E. P. Fitzgerald, Chance, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal. *Remarks:* Out of business 1930.



Figure 40. The Warner Coal Mine at Lodgepole

WARNER COAL MINE: *Location:* Near Lodgepole, 20 miles from Hettinger, N. Dak. *Ownership:* Joe A. Warner, (Warner Bros.) Lodgepole, S. Dak. *Type of Deposit:* Flat-lying beds. *Valuable Mineral:* Lignite coal. *Development:* By drifts and inclines. *Remarks:* 3 men employed 8 months a year. *Annual Production:* 2,000 tons.

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PART IV

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